THE

POPULAR SCIENCE MONTHLY.

JANUARY, 1877

THE EARLIER FORMS OF LIFE.

By Professor C. H. HITCHCOCK,
STATE GEOLOGIST OF NEW HAMPSHIRE.

THE surmises and discoveries of the past twenty years have established the fact of the existence of life throughout the entire series of stratified rocks known to geologists, both sedimentary and metamorphic. When Principal Dawson published his description of the Eozoön in the Laurentian foundations, he was led to suggest the adoption of the term *Eozoic* in place of *Azoic* for all the ages older than Paleozoic, since, if life existed in the oldest formation, it must have continued to flourish in the following æons, even though evidences of its presence had not then been accumulated. Time has approved of this sagacious anticipation, and we can now maintain with serene confidence that the four great Eozoic periods—Laurentian, Labrador, Atlantic or Montalban, and Huronian—were all enlivened by the existence of both vegetable and animal life. And Eozoic life had its peculiar characteristics just as much as the Silurian or Carboniferous.

This life has appeared in consonance with the general principles of evolution as announced by our most learned sages. The earliest organic forms were the simplest in their structural relations; and they flourished through untold ages. The world was no longer young when the organic scheme permitted the growth of Cambrian trilobites and mollusca. More than half of geological time had passed away during the reign of protozoans and fungi. This suggests the enunciation of a general principle, in perfect agreement with the doctrines of evolution: the simpler the predominating forms of life the longer the period. In the beginning of Nature's operations, time was the element of which lavish use was made. It has grown more valuable as the ages have passed on, and the perfected type of organic development in our period grudges the loss of a single moment of it.

The evidences of the earlier forms of life naturally divide them-

selves into two groups, or those relating to plants and animals, which we will consider in their natural order:

Evidences of Plant-Life.—An interesting evidence of the existence of vegetation in Eozoic times is derived from the presence of iron-ores, an argument first set forth by Sterry Hunt. The ores are first formed in the hydrated condition, and then lose their water by metamorphic agencies, becoming specular and magnetic, or the state in which the Laurentian irons are now known. Ores of iron are conceived to have been formed under similar conditions in all ages. At the present day they accumulate in swamps and low grounds in the condition of the hydrated peroxide (ferric), or bog-ore, oftentimes in company with manganese. The presence of organic vegetable matter is requisite in order to extract the iron from the rock or soil and effect its deposition. The metal present in slight amount in the soil is the insoluble ferric oxide, or the familiar condition of iron-rust. Water charged with soluble vegetable infusions, like that in swamps too full of the disagreeable extract of leaves, etc., to be palatable, has the power of dissolving ferric oxide. The process consists in the removal of a part of the oxygen by the vegetable compound, or deoxidation, when the compound becomes changed into the readily-soluble ferreous oxide. But this is not a stable compound in the presence of our atmosphere. The rejected oxygen is brought back again, and in its recombination takes water with it, producing the hydrated ferric oxide, which, being insoluble, is precipitated, and covers the ground on the bottom of the pool. On visiting almost any swamp at the present day, this reddish-brown coating of hydrated iron-rust may be seen abundantly. Where streams of water cause the swampy water to flow to lower regions, the iron compound is also conveyed in suspension, and in the course of a few years a thick deposit of ore is accumulated. Our New England ancestors used these beds for the manufacture of their pig-iron in localities where only the name now exists for the village, such as the Tamworth or Gilmanton Iron-Works. All tradition of the manufacture there has disappeared. The Katahdin Company, in Maine, however, and some others, still derive their ore-supplies from this bog-compound.

Our theory supposes that the principal iron-ores in every age of the world had their origin in this way. There is no other agent save this organic extract which produces iron-ore on a large scale at the present day; hence it is rational to explain the origin of ancient ferruginous beds in the same way. If we examine the formations in order, we find the very ores themselves obviously thus accumulated: 1. There are the early Tertiary limonite beds of Western New England, New Jersey, and Pennsylvania, still scarcely removed from the bog form, with the accompanying clays. 2. There are the older Carboniferous nodules and the celebrated Clinton hematites, differing from the limonites only by the absence of water. 3. The specular

Huronian ores of Lake Superior have the same composition as the Silurian deposits. Lastly, the Laurentian magnetites constitute the other extreme of the ferruginous series. Both the water and a part of the oxygen have disappeared, leaving a compound richer in metal, and therefore more highly prized by the smelter. The application of a gentle, continuous heat is adequate to explain the change of the limonites into hematites and magnetites.

The process of change may be seen in the manufacture of common bricks, or the purification of quartz for the production of glass. The blue clay becomes red when burned, because it parts with its water of composition; and likewise the small percentage of hematite in the quartz becomes magnetic on the application of heat, and, after pulverization, has the iron removed by magnets, so that the silica-flour may be perfectly pure, and not impart a green tint to the glass. It is not maintained that the native limonites have been converted into magnetites in precisely the way in which the same results have been accomplished artificially; but the manipulation of the manufactured products shows that the metamorphosis is a feasible process, and by no means of difficult accomplishment in Nature.

In a review of a report by the author, in which this theory of iron-ore origin is elucidated, Prof. Dana objects[1] to its value, because "carbonic acid, which does now some of the work of iron-transportation, may have done far more then," on account of its presence in the atmosphere in great abundance. No doubt exists as to the assistance afforded by carbonic acid in this work, but this fact only confirms the truth of our argument, since no chemist will allow that carbonic acid can remove the iron-rust from the soil without the help of some deoxidating agent, such as vegetation. The chemical change for which we require the presence of vegetation is the same, whether carbonic acid be involved or not. Indeed, an excellent authority for the form in which this change is effected is the professor's own treatise on mineralogy,[2] where he says, "The iron is transported in solution as a *protoxide* carbonate in carbonated waters, a sulphate, or as a salt of an organic acid." Each of these methods requires the presence of a deoxidating agent like vegetation; and nothing better has yet been suggested. The iron-ores produced by volcanic ejections are of very limited amount, and mingled with too much dead rock to be capable of utilization. Nor does the suggestion of the decomposition of pyrites by atmospheric agents to form limonite necessitate the origin of all iron-ores in that way.

Accepting the validity of the argument, it follows that vegetation must have been extremely abundant in the Laurentian and Huronian ages on account of the presence in them of enormous deposits of iron-ores, as on Lake Superior, in the Adirondacks, Missouri, etc. Some of the beds are hundreds of feet in thickness.

[1] *American Journal of Science*, iii., vol. ix., p. 223. [2] Fifth edition, p. 173.

The presence of graphite, or plumbago, in the Eozoic rocks is by many regarded as a still stronger argument for the former existence of vegetation. As graphite is nearly pure carbon, it is easy to believe that it has accumulated from the remains of plants. Greater changes have been effected in its mass through metamorphism than in the alterations of the ore-beds. No traces of vegetable structure have yet been detected in graphite, so that no evidence as to the nature of the earliest plants can be afforded from morphology.

Nature of the Eozoic Flora.—What species of vegetation can we imagine to have existed in these early periods? Possibly we may derive a hint as to its nature from the general course of plant-development in later ages, and assume that there has been a correspondence between the order in which the different classes have appeared and their successive stages of complexity of structure. The simpler forms should appear first; or, reversing the statement, if we find a succession of all the higher forms of growth in later times, it is reasonable to expect in the still earlier periods larger developments of the inferior cryptogams, such as now play a comparatively insignificant part in the economy of Nature. Their easy decomposition would prevent the preservation of their specific shapes as fossils.

To particularize, we have among the lower orders of terrestrial vegetation the lichens, by some thought to be the parent of the fungi and algæ, since they can be resolved into two different plants, a fungus parasitic upon an alga; the mushrooms, puff-balls, mildews, blight, or fungi; the hepaticæ, and mosses. Of aquatic vegetation there are the numerous protophytes, the diatoms, with their siliceous shells; the desmids, the coccoliths, with their lenticular calcareous disks; the nullipores and corallines, making calcareous incrustations; and the great family of Algæ, simple, branched, and confluent. These afford us abundant material from which we may reconstruct the Eozoic meadows, forests, and submarine carpets.

The present system of plants seems to have originated in the Cretaceous period. The older Mesozoic gives us the cycads and tree-ferns, like those of the Asiatic tropics. The Paleozoic formations furnish a unique assemblage of combined cryptogamous and phenogamic nature of types not now existing. Granting that the two divisions of the plant kingdom are of equal importance in the line of development, we find ourselves in Silurian times only half-way back to the starting-point. If the Cambrian should furnish us with representations of the mosses and lichens, we might expect in Eozoic times some of these, together with the protophytes, etc., in order to complete the systematic and orderly development of the plant kingdom in time. Furthermore, the later ages have afforded gigantic representations of the higher orders. Why, then, should not the Eozoic land have had its forests of mushrooms and arborescent lichens; its swamps of diatoms, confervæ, the charæ and desmids,

and enormous aquatic growth of algæ, coccoliths, nullipores, and corallines? If we grant that the parasitic fungi could not exist for want of their proper organic food of higher organization, there are still enough forms remaining to take their place, and thus afford us a symmetrical development of all the phases of vegetable growth in the enormous periods when the simplest organic structures ruled the world.

Evidences of Animal Life.—It has been argued by high authority that the existence of carbonate and phosphate of lime suggests the presence of animal life in the Laurentian seas, because at the present day these mineral substances are principally derived from organic secretions. The graphite may also have been partly of animal derivation. There is as much carbon in the Laurentian as in the Paleozoic Carboniferous. But these indications need not be dwelt upon, since recent discoveries have brought to light the actual relics of protozoans preserved in stones of Laurentian age. These are so convincing that the discussion of probabilities derived from rocks of supposed organic origin need not be dwelt upon. The organism has the name *Eozoön Canadense*, the *dawn-animal*, inhabiting the Canadian district.

Several names are connected with the discovery of this *Eozoön* from Ontario and elsewhere. Dr. Wilson, of Perth, sent specimens of it many years since to Sir William E. Logan, Director of Canadian Geological Survey, in which Dr. Sterry Hunt found a new hydrous silicate, which he called Loganite. In 1858 J. McMullen brought specimens which reminded Logan of the *Stromatopora* of the Silurian. They were examined by various scientists, and in 1865 a composite paper upon the geology, paleontology, and mineralogy of the fossil appeared in the journal of the Geological Society of London, prepared by Messrs. Logan, Dawson, Carpenter, and Hunt. Soon after Vennor discovered other specimens in the Montalban of Tudor, Ontario; Gümbel recognized it in both the Laurentian and Huronian in Bavaria; Bicknell and Burbank discovered it in Laurentian limestones at Newbury and Chelmsford, Massachusetts; and Edwards described it from the Adirondacks in New York. Scientists have not universally accepted the genuineness of this fossil. I will endeavor to present a brief sketch of the nature of the organism before stating their objections.

This animal structure belongs to the subkingdom Protozoa, a unique and inferior group of organisms. These animals are distinguished by possessing no alimentary cavity, or, if a stomach be present, it is not bounded by any walls. The three divisions, using the classification adopted by Dawson, are: the *Rhizopods*, *Sponges*, and *Infusoria*. The first is the lowest, including all the sarcodous animals whose only external organs are pseudopodia. The rhizopods are divided into the *Reticularia* or *Foraminifera*, possessing thread-

like and reticulating pseudopodia with granular matter instead of a nucleus, and with calcareous, membranous, or arenaceous skeletons; the *Radiolaria* and *Lobosa*, the first being the lowest, and embracing Eozoön. The reticularia may be still further divided into two suborders, *Perforata* and *Imperforata*, the first having calcareous skeletons penetrated with pores. This is the higher one, and holds Eozoön. Of the three families *Nummulinidæ*, *Globigerinidæ*, and *Lagundæ*, Eozoön belongs to the first and the highest in rank. It is not strictly, then, the lowest of the animal kingdom, though very near to it.

Fig. 1 shows several species of the foraminifera.

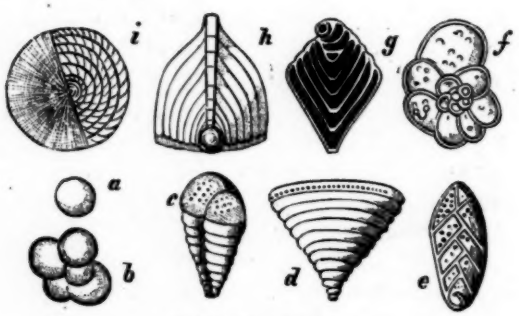


FIG. 1.—RHIZOPODS.

a, Orbulina universa; *b*, Globigerina rubra; *c*, Chrysalidina gradata; *d*, Cuneolina pavonia; *e*, Grammostomum phyllodes; *f*, Rotalia globosa; *g*, Flabellina rugosa; *h*, Frondicularia annularis; *i*, Nummulites nummularia.

The animal part of the rhizopods is a gelatinous body called sarcode, a bit of scarcely-organized protoplasm. Food is taken in through the outer wall, and is made into small pellets, which are surrounded by a digestive fluid in extemporized stomachs. Minute granules move about the interior, perhaps the substitute for a circulating fluid; and the outer wall can be moulded into the long processes called pseudopodia, used for locomotion and prehension. When these rhizopods secrete stony matter for a covering, the interior is the same structureless mass; but the shells assume characteristic forms for the different varieties. The *Orbulina* consists of a single cell with one orifice, but permeated by numerous microscopic pores, through which the protoplasmic material can ooze and form the pseudopodia. In the *Globigerina* and other genera there are several cells agglutinated together, all communicating with one another. In many species the thin cell-wall is inadequate for the wants of the structure, and an additional growth or "supplementary skeleton" is added, traversed by tubes larger, longer, and more branched, than in the first. In the ocean these minute creatures swarm in astonishing numbers, and their remains accumulate at the bottom, commingled with a paste of still more minute coccoliths and calcareous *débris* to form the ooze brought up in the sounding-lead from the telegraphed plateau. When

this calcareous mixture becomes solidified it is the chalk which abounds in the Cretaceous formation of Europe, and makes up the nummulitic and orbitoidal limestones.

Fig. 2 is a close copy of a small slab of Eozoön, showing what are called the laminated, acervuline, and fragmental portions. The diagonal white line represents the course of a vein of calcite. The dark lines and marks correspond to the sarcode or animal matter of the animal, now consisting of serpentine. Calling the base of the

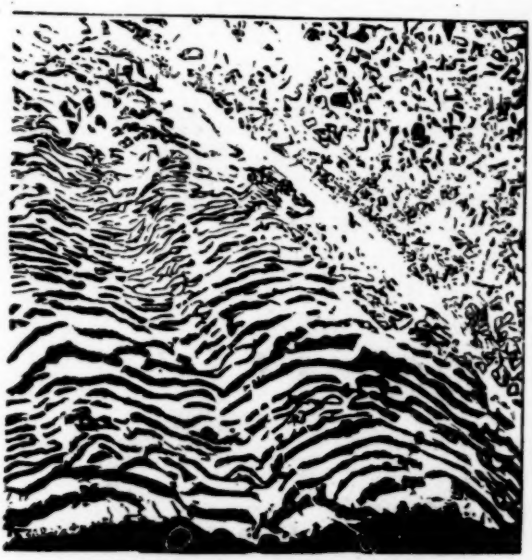


Fig. 2.—Nature-Print of Eozoön. (Dawson.)

figure the ocean-floor, there may be said to grow upon it the gelatinous sarcode or dark mass. Upon it grew first the delicate calcareous shell, penetrated by the numerous minute orifices or tubuli, larger pores, and occasionally supports of perpendicular plates. Added to this is the supplemental skeleton without the minute tubuli, but traversed by branching canals. This whole skeleton is represented by the white mass next the dark base, consisting of calcite. These two layers or laminæ constitute the essential part of the structure, and all the numerous layers above are but repetitions of them. Each lamina may cover several inches square of surface at the bottom of the ocean, and perhaps diminish in size as the organism grew upward. In the sketch the layers are seen to grow thinner toward the top, as if the vital energy became exhausted by the demands made upon it, and the supplemental skeleton first disappears. Finally, we have a mass of rounded chambers irregularly piled up near the top, constituting the "acervuline" structure. We may suppose the growth arrested at this stage, and the sending forth of reproductive germs to found new colonies in the adjacent ground.

In Fig. 3 we have an enlarged restoration, after Dawson, of a portion of the Eozoön structure, which will enable us to better appreciate the several parts of the organism. The dark, granulated layers at the base and at intervals higher up constitute the chambers, and contain the sarcode or gelatinous animal matter. Immediately above and below each dark layer is the thin calcareous shell penetrated by the minute orifices or tubuli. The white spaces represent the supplementary skeletons traversed by the larger canals. At the summit the sarcode is developed into several pseudopodia or cilia, by means of which food is brought to be assimilated.

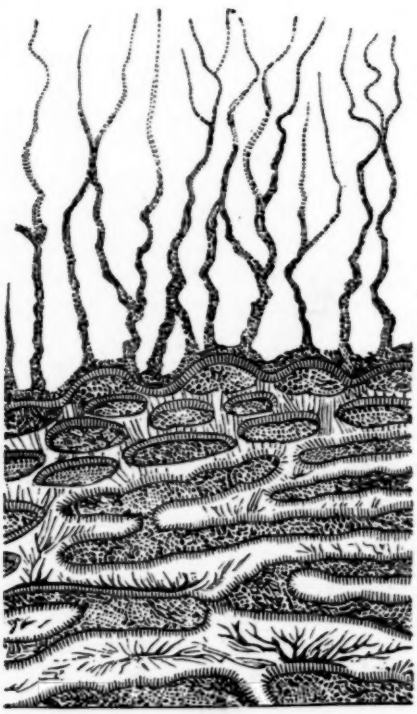


FIG. 3.—EOZOÖN RESTORED. (After Dawson.)

In Fig. 4 we have a portion of Eozoön magnified one hundred diameters, drawn by Carpenter. The upper covering (*a a*) represents the original cell-wall penetrated by the tubuli or pores in great abundance. A bit of this is still more magnified in 2, by the side of the first, seemingly consisting of an upper and lower part. The greater part of the sketch consists of the supplemental or intermediate skeleton, traversed by two kinds of canals (*b*, *c*), of much larger size and greater irregularity than the tubulation of the cell-wall.

The arrangement and composition of the mineral matter of the Eozoön is quite interesting, and the more remarkable since it has

awakened hostile criticism and resulted in illustrating the presence of silicates in organisms in every age of the world. Formerly it was believed that carbonate of lime was the principal mineral found replacing organic substances, thus producing petrifactions. Now we have iron oxide, silica, clay, sand, sulphuret of iron, ores of copper, lead, etc., fluor-spar, heavy spar, phosphate of lime, all unmistakably occu-

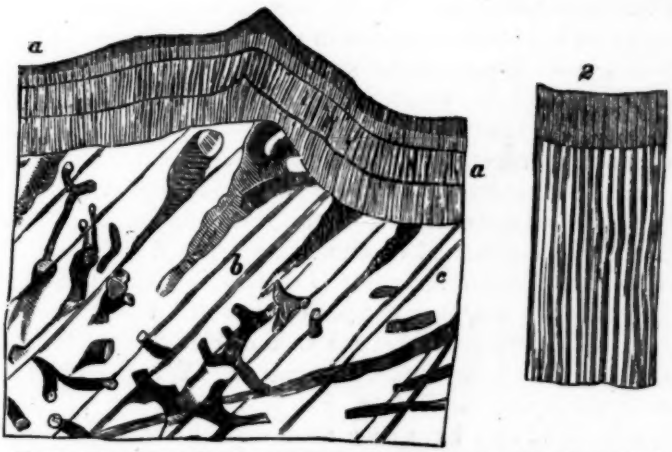


FIG. 4.—PORTION OF EOZOÖN MAGNIFIED 100 DIAMETERS. (After Carpenter.)
a a, Original cell-wall with tubulation; *b c*, Supplementary skeleton, with canals; 2. Portion of *a a* magnified.

pying the place of decomposable organic material. And the discussions about Eozoön recall and enforce facts about the employment of silicates by Nature to preserve her structures, especially in foraminiferal forms. In New Jersey there are beds of green-sand of Cretaceous and Tertiary ages full of concretions composed of a silicate of iron and potash called *glauconite*. Owing to its value as a fertilizer, thousands of tons of it are annually employed by the farmers to enrich their lands. This silicate has replaced modern organic structures of various kinds, but noticeably corals, echinoderms, nummulites, and other rhizopods. The fine tubulation and pores of these microscopic structures have been penetrated by the silicates, so that, when the calcareous parts have been removed by acid, the insoluble glauconite residue shows us the forms of the chambers and cavities. This process of the infiltration of organisms by glauconite was known long before the discovery of Eozoön. It goes on at the present day at the bottoms of the warmer seas, as evidenced in the facts discovered by the numerous deep-sea dredgings recently undertaken in the interests of science. Dr. Hunt suggests that the mineral is developed through chemical reactions in the ooze at the sea-bottom, a combination of dissolved silica with iron put into the ferrous soluble condition by means of organic matter.

Hydrous silicates act as mineralizers elsewhere than in the greensand. Crinoidal joints from the Silurian limestones of New Brunswick have been saturated by it, filling all the interstices, and small mollusks from Wales have had their interior permeated by it. There is much variation in the composition of these infiltrating silicates. Some from the *calcaire grossier*, near Paris, approach serpentine. Others carry magnesia. Those from the Lower Silurian of the Upper Mississippi Valley are like glauconite. In the Eozoön, as described above, serpentine, which is a hydrous silicate of magnesia, replaces the supposed sarcodous or animal part of the structure. It has thus corresponded to the glauconite of the present day filling the canals of the supplementary skeleton, the tubuli of the shell, and replacing the softer animal portions. Pyroxene and Loganite also replace the animal matter in the Canadian Laurentian fossils, and in the Eozoön discovered in the supposed Montalban series of Ontario carbonate of lime is the mineralizer. These last-named specimens were not described till 1867; and, as they exhibit the foraminiferal structure without the presence of any form of silicate, they completely establish the genuineness of the fossil. In Bavaria Gümbel states that chondrodite, hornblende, and scapolite, and perhaps other minerals, should be added to the list of silicates petrifying the Eozoön.

The objections that have been made to the organic character of Eozoön relate chiefly to the close resemblances between mineral and organic replacement, or between pseudomorphs and petrifactions. Other resemblances are to dendritic and concretionary structures. Inasmuch as these structures represent the higher efforts of the mineral kingdom in crystallization and the nearest approach to the inorganic world allowed by animal forms, it is not strange that the two extremes should resemble each other sufficiently to deceive practical observers. The canal system may be almost the very picture of certain dendrites. The latter, however, usually occupy a flat surface like moss-agates; whereas the former branch out in every direction, as appears in Fig. 5, projecting upward and downward, as well as sideways.

Organisms are preserved because of the more or less complete substitution of mineral for animal matter. Pieces of coal or wood that have been deposited in clay may be washed out, but the small pores and interstices will be seen to be filled with the matrix. When the burial has been in a solution capable of precipitating solid matter, the wood will be found more or less changed according to the nature of the solution and its capacity for alteration. Some specimens become nearly pure agate in consequence of the gradual substitution, particle by particle, of the organic matter by silica. Fig. 6 shows different stages of petrifaction in coniferous wood: *a* is a small fragment where the pores have been filled with silica, assuming a somewhat rhomboidal appearance, and the black parts represent the woody substance, still intact; in *b* the vegetable matter is wanting, having rotted away,

and only silica remains, the rhomboidal pieces being the only remnants of the original structure. The Eozoön has not been so completely fossilized as in the example of coniferous wood. The cell-wall and supplementary skeleton still retain much of the original lime, while the animal part has been entirely replaced by serpentine or some other mineral. Subsequent pressure or desiccation has produced cracks in the mass, which have been filled with an asbestus-like mineral of silky lustre, and this has sometimes been confounded with some part of the animal by objectors.

FIG. 5.—CANALS OF EOZOÖN, HIGHLY MAGNIFIED.

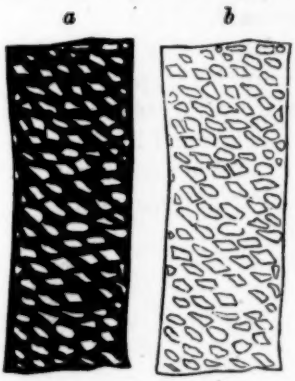


FIG. 6.—CONIFEROUS WOOD, ILLUSTRATING FOSSILIZATION.

a, Partially mineralized, the white spaces being silica, the black vegetable matter; *b*, Vegetable matter removed by decomposition, leaving outline of the forms of the original pores.

Few special subjects have been so carefully studied as the genuineness of Eozoön. The treatises of Logan, Dawson, Carpenter, and Hunt, admirably set forth every possible phase of geological position, intimate zoölogical structure and affinity, mineral character both original and derived, and the conditions of origination. The elaborate papers of the objectors, Messrs. King, Rowney, Carter, Burbank, and others, show what the weaker positions are, and have enabled the advocates to satisfactorily fortify the less defensible points of their arguments. Every new discovery seems to aid the defenders, while the philosophy of evolution is in harmony with the existence of a long Eozoöic age where the predominant life is scarcely elevated above the working of crystalline forces.

HURONIAN LIFE.—Gümbel has described a species of Eozoön from the supposed Huronian rocks of Bavaria. In this country Billings has mentioned the occurrence of an *Aspidella* and *Arenicolites* from a series of Newfoundland rocks called "Intermediate," most probably of this age. The *Aspidella* bears some resemblance to the limpet-shell or *Patella*, while it may have been some variety of crustacean. The *Arenicolites* is a petrified worm-burrow.

But the specimens of greatest interest are those brought to light the present year by Mr. George W. Hawes from the Huronian of

New Hampshire.[1] The rocks have been carefully studied stratigraphically and lithologically, so that their place in the column is well understood, and the fossil is so allied to the Eozoön as to abundantly confirm all that has been held for it by its warmest advocates.

As a matter of convenience Mr. Hawes proposes to call the group of rocks affording these organisms *greenstones*, in allusion to their color. They have not been melted like a certain class of traps once called by this name, but have been metamorphosed somewhat; they embrace most of the chloritic and talcose schists, or, technically, "all basic metamorphic rocks whose predominant coloring ingredient is either hornblende, pyroxene, or chlorite." Those of special interest to us now are varieties of diorite and diabase, the first consisting mainly of hornblende and feldspar, the second adding labradorite to the constituents of the first-named rock. These rocks by many authors are regarded as of igneous origin.

FIG. 7.—PROTOZOAN FOSSIL, PROBABLY STROMATOPORA, FROM CONNECTICUT LAKE, N. H.

The method of examination employed in determining the composition of these greenstones is of some interest. A bit of the specimen is carefully ground to the thinnest dimensions possible, so that it can be examined optically under the microscope. With common and polarized light it is possible to understand the nature of the minutest minerals present, as well as the cavities contained in them. The study of rocks in this way has been prosecuted so energetically of late, that it is common to speak of the sub-sciences micro-lithology, micro-petrology, etc., and the appearances of every mineral are now well understood by those skilled in observation, so that the conclusions are often more reliable than those obtained by ultimate chemical analysis. Mr. Hawes combines in his studies the use of the microscope and chem-

[1] *American Journal of Science*, iii., vol. xii., p. 134.

ical analysis, so that whatever cannot be determined in the one will be ascertained by the other method.

He was accordingly gratified to recognize in one of his rock-sections the fragment of a rhizopod. The structure has some resemblance to the acaleph *Chætetes*, but on account of the minuteness of the layers it should be classed with the rhizopods, reminding one very much of the *Stromatopora*. Figs. 7 and 8 illustrate these organisms magnified thirty-five diameters, thus making the breadth of the cells only $\frac{1}{280}$ of an inch. The smaller figure is probably a section of the

FIG. 8.—PROTOZOAN FOSSIL, FROM HANOVER, N. H.

same rhizopod, cut in a different direction. The rock holding these fossiliferous bits is diabase, a variety common between Connecticut Lake and Bellows Falls, both in New Hampshire and Vermont.

Since the naming of *Stromatopora* by Goldfuss fifty years since, naturalists have separated the acaleph structures from the true corals, but this genus is generally regarded as different from either of them. Prof. Hall described it as a polyp-coral in his "Paleontology of New York," but would not so regard it now. The most common form of it, as figured by him, is herewith presented (Fig. 9), from the Niagara limestone of Lockport, occurring in masses one or two feet in diameter. It is a protozoan coral, assisting in the work of reef-building, however, as much as the polyp-structures. By way of comparison we add a figure of a bryozoan mollusk (*Lichenalia concentrica*), from the same formation and locality with the *Stromatopora* (Fig. 10). The relations of our new specimens are rather with the first of these forms, and will probably be described hereafter as species of *Stromatopora*.

It is an interesting fact that these "layer corals" have impressed the minds of all students of the Eozoön by their resemblances to the

dawn-animal. Logan speaks of it in his first remarks upon them, referring more particularly to their weathered outcrops and somewhat concentric structure; while Dawson sees much in their internal organization suggestive of a fitness for foraminiferal requirement. The layer seems better arranged for sheltering a gelatinous body, throwing out pseudopodia reaching after food, than for accommodating the

FIG. 9.—STROMATOPORA CONCENTRICA. (Goldf.)
1. Surface of a small hemispheric mass, showing the edges of the thin laminæ unequally weathered, natural size.
2. Magnified portion, showing weathered edges of successive laminæ, which are indented by pores.
3. More highly-magnified portion of the specimen, showing the walls and tubulation.

sponge animals, subsisting through the passage of currents of water. The canal system, with the supplemental skeleton, is wanting in this genus, but appears in the allied forms of the Devonian.

A very important feature of the greenstone fossils is their mineral composition. They are composed of silicates, very probably of feldspar. Mr. Hawes has not been able yet to satisfy himself fully as to the nature of the silicate, because of the smallness of the particles obtained. A drop of acid placed upon one of the specimens exhibited a slight effervescence, indicating the traces of carbonate of lime—perhaps part of the original foraminifer before its fracture and dispersion in the mud. He suggests that the presence of these lime-structures afforded the material for the manufacture of so much labradorite in the diabases containing the fossils.

I cannot forbear alluding to the interesting confirmation of the genuineness of Eozoön afforded by the discovery of these Huronian fossils in New Hampshire: 1. Eozoön sprung upon us with affinities rather remote from existing forms, but the *Stromatopora* has been known for fifty years as a veritable organism. 2. The latter has the same silicated condition with the former; hence we cannot set aside Eozoön merely because the supposed animal parts have been infiltrated

FIG. 10.—LICHENALIA CONCENTRICA. (Hall.)
1. A nearly perfect frond.
2, 3. Enlargements of the non-celluliferous side, showing the form and arrangement of the stigmata.

by a silicate. A well-known organism is proved to be silicated; hence all presumption against the existence of the same mineral condition in a related animal is removed. 3. *Stromatopora* is zoölogically allied to Eozoön. 4. It appears in a subsequent period, showing a natural order of development. 5. Stratigraphical and petrographical studies prove the greenstones to satisfactorily belong to the true Huronian formation, and thus make the sequence of life free from ambiguity.

EOZOIC GEOGRAPHY.—Such vast periods are necessarily involved in those early stages of the earth's growth, that we cannot portray

Eozoic scenery as a whole; while an artist would find material for only one sketch. At the first we must conceive of an earth with a larger diameter than is now accepted as the standard for the metric system of measures; of a shallow ocean covering the greater portion of the surface, interspersed with numerous islands, scattered everywhere without any method of arrangement that we understand. In the areas marked as Eozoic upon our maps, accumulations of strata were going on, of enormous thickness. We cannot recognize now the original land which supported the primeval vegetation, but can conjecture the boundaries of the contiguous oceans. In the latter part of the period the areas of deposition occupied basins situated within the limits of the earlier-formed rocks, being usually the deeper portions of the original oceans. Ridges between the water-basins resulted from the slow elevation of the land, the nuclei of great mountain-ranges, and there were ejections of melted matter, with marvelous alterations of sediments deep down beneath the surface.

Respecting the age as a whole, we may say that the waters were probably somewhat thermal, still simmering from the proximity of the heated interior; the air was thick and moist, partly composed of carbonic-acid gas; the sky was filled with dense clouds, marking the transition of day and night by periods of total darkness and seasons of feeble illumination, not permitting sunshine to cheer the vegetation. The life was characterized by its lowness of grade; the terrestrial plants hardly suitable for the food of air-breathing animals; the marine largely of the lime-secreting varieties and unicellular diatoms. The animals colonized the bottoms of the oceans, building up enormous reefs, but invisible to sight, if any one could have been permitted to look upon the infant world.

THEORIES OF PRIMITIVE MARRIAGE.[1]

By HERBERT SPENCER.

IN his ingenious and interesting work on "Primitive Marriage," the words "exogamy" and "endogamy" are used by Mr. McLennan to distinguish the two practices of taking to wife women belonging to other tribes, and taking to wife women belonging to the same tribe. As explained in his preface, his attention was drawn to these diverse customs by an inquiry into "the meaning and origin of the form of capture in marriage ceremonies;" an inquiry which led him to a general theory of early sexual relations. The following out-

[1] From advance-sheets of Spencer's "Principles of Sociology," Part "The Domestic Relations," chap. iv., "Exogamy and Endogamy."

line of his theory I disentangle, as well as I can, from statements that are not altogether consistent.

Scarcity of food led groups of primitive men to destroy female infants; because, "as braves and hunters were required and valued, it would be the interest of every horde to rear, when possible, its healthy male children. It would be less its interest to rear females, as they would be less capable of self-support, and of contributing, by their exertions, to the common good" (p. 165).

Mr. McLennan next alleges that "the practice in early times of female infanticide," "rendering women scarce, led at once to polyandry within the tribe, and the capturing of women from without" (p. 138).

Joined with a restatement of the causes we come upon an inferred result, as follows: "The scarcity of women within the group led to a practice of stealing the women of other groups, and in time it came to be considered improper, because it was unusual, for a man to marry a woman of his own group" (p. 289). Or, as he says on p. 140, "usage, induced by necessity, would in time establish a prejudice among the tribes observing it (exogamy)—a prejudice, strong as a principle of religion, as every prejudice relating to marriage is apt to be—against marrying women of their own stock."

To this habitual stealing of wives, and restealing of them, as among the Australians (p. 76), he ascribes that doubtful paternity which led to the recognition of kinship through females only. Though elsewhere admitting a more general cause for this primitive form of kinship (p. 159), he regards wife-stealing as its most certain cause, saying that "it must have prevailed wherever exogamy prevailed—exogamy and the consequent practice of capturing wives. Certainty as to fathers is impossible where mothers are stolen from their first lords, and liable to be restolen before the birth of children" (p. 226).

Assuming the tribes which thus grew into the practice of wife-stealing to have been originally homogeneous in blood, or at least to have supposed themselves so, Mr. McLennan argues that the introduction of wives who were foreigners in blood, joined with the rise of the first definite conception of relationship (that between mother and child) and consequent system of kinship exclusively in the female line, led to recognized heterogeneity within the tribe: there came to exist, within the tribe, children regarded as belonging by blood to the tribes of their mothers. Hence arose another form of exogamy. The primitive requirement that a wife should be stolen from another tribe, naturally became confounded with the requirement that a wife should be of the blood of another tribe; and hence girls born within the tribe, from mothers belonging to other tribes, became eligible as wives. The original exogamy, carried out only by robbing other tribes of their women, gave place, in part, or wholly, to the modified

exogamy carried out by marrying, from within the tribe, women bearing family names which implied that they were foreign in blood.

In tracing the development of higher forms of the domestic relations, Mr. McLennan postulates, as we have seen, that the scarcity of women "led at once to polyandry within the tribe, and the capturing of women from without." Describing and illustrating the different forms of polyandry, ending in that highest form in which the husbands are brothers, he points out that at this stage there arose recognition not only of descent in the female line, but also of descent in the male line; since the father's blood was known, if not the father.

Then through gradually-established priority of the elder brother, as being the first of the group to marry, and the first likely to have children, it became an accepted fiction that all the children were his: "the elder brother was a sort of *paterfamilias;*" and "the idea of fatherhood" thus caused was a step toward kinship through males, and "a step away from kinship through females" (pp. 243, 244).

Pointing out that among some polyandrous peoples, as the Kandians, the chiefs have become monogamists, Mr. McLennan argues (p. 245) that their example would be followed, and "thus would arise a practice of monogamy or of polygamy." And he thence traces the genesis of the patriarchal form, the system of agnation, the institution of caste.

Though this outline of Mr. McLennan's theory is expressed, wherever regard for brevity permits, in his own words, yet possibly he may take exception to it, for, as already hinted, there are incongruities in his statements, and the order in which they are placed is involved. That many of the phenomena he describes exist, is beyond question. It is undeniable that the stealing of women, still habitual with sundry low races, was practised in the past by races now higher; and that the form of capture in marriage ceremonies prevails in societies where no real capture occurs at present. It is undeniable that kinship through females is, among various primitive peoples, the only kinship avowedly recognized; and that it leads to the descent of name, rank, and property, in the female line. It is undeniable that in many places where wife-stealing is, or has been, the practice, marriage is forbidden between those of the same family name, who are assumed to be of the same stock. But while admitting much of the evidence, and while accepting some of the inferences, we shall find reason for doubting Mr. McLennan's theory taken as a whole. Let us consider, first, the minor objections.

Sundry facts inconsistent with his conclusion, though referred to by Mr. McLennan, he passes over as of no weight. He thinks there is warrant for the belief that exogamy and wife-capture have "been practised at a certain stage among every race of mankind" (p. 138): this stage being the one now exemplified by sundry low races. Nev-

ertheless, he admits that "the separate endogamous tribes are nearly as numerous, and they are in some respects as rude, as the separate exogamous tribes" (p. 145). Now, if, as he believes, exogamy and wife-stealing have "been practised at a certain stage among every race of mankind"—that stage being the primitive one—and if, as he seeks to prove, endogamy is a form reached through a long series of social developments, it is difficult to understand how the endogamous tribes can be as rude as the exogamous ones.

Again, he names the fact that "in some districts—as in the hills on the northeastern frontier of India, in the Caucasus, and the hill-ranges of Syria—we find a variety of tribes, proved, by physical characteristics and the affinities of language, of one and the same original stock, yet in this particular differing *toto cœlo* from one another—some forbidding marriage within the tribe, and some prescribing marriage without it" (pp. 147, 148): a fact by no means congruous with his hypothesis.

Should Mr. McLennan reply that on pp. 47, 48, he has recognized the possibility, or probability, that there were tribes primordially endogamous—should he say that on pp. 144, 145, will be found the admission that, perhaps, exogamy and endogamy "may be equally archaic," the rejoinder is that, besides being inconsistent with his belief that exogamy has "been practised at a certain stage among every race of mankind," this possibility is one which he practically rejects. On pp. 148–150, he sketches out a series of changes by which exogamous tribes may eventually become endogamous; and in subsequent sections on the "Growth of Agnation," and "The Rise of Endogamy," he tacitly asserts that endogamy has thus developed: if not without exception, still, generally. Indeed, the title of one of his chapters—"The Decay of Exogamy in Advancing Communities"—clearly implies the belief that exogamy was general, if not universal, with the uncivilized; and that endogamy grew up along with civilization. Thus the incongruity between the propositions quoted in the last paragraph cannot be escaped.

Sundry other of Mr. McLennan's statements and inferences conflict with one another. Assuming that, in the earliest state, tribes were stock-groups "organized on the principle of exogamy," he speaks of them as having "the primitive instinct of the race against marriage between members of the same stock" (p. 118). Yet, as we have seen above, he elsewhere speaks of wife-capture as caused by scarcity of women within the tribe; and attributes to this "usage, induced by necessity," the prejudice against "marrying women of their own stock." Moreover, if, as he says (and I believe rightly says) on p. 145, "men must originally have been free of any prejudice against marriage between relations," it seems inconsistent to allege that there was a "primitive instinct" "against marriage between members of the same stock."

Again, while in some places the establishment of the exogamous prejudice is ascribed to the practice of wife-stealing (pp. 53, 54, and 136), it is elsewhere made the antecedent of wife-stealing: interdict against marriage within the tribe was primordial. Now, if this last is Mr. McLennan's view, I agree with Sir J. Lubbock in thinking that it is untenable. It cannot be assumed that in these earliest groups of men, with which Mr. McLennan commences, there were any established rules of marriage. Unions of the sexes must have preceded all social laws. The rise of a social law implies a certain preceding continuity of social existence; and this preceding continuity of social existence implies the reproduction of successive generations. Hence reproduction, entirely unregulated by interdicts, must be taken as initial.

Assuming, however, that of his two views Mr. McLennan will abide by the more tenable one, that wife-stealing led to exogamy, let us ask how far he is justified in alleging that female infanticide, and consequent scarcity of women, led to wife-stealing. At first sight it appears undeniable that destruction of infant girls, if frequent, must have been accompanied by a deficiency of adult females; and it seems strange to call in question the legitimacy of this inference. But Mr. McLennan has overlooked a concomitant. Tribes in a state of chronic hostility are constantly losing their adult males, and the male mortality so caused is usually considerable. Hence the killing many female infants does not necessitate paucity of women: it may merely prevent excess. Excess must, indeed, be inevitable if, equal numbers of males and females being reared, some of the males are from time to time slain. The assumption from which Mr. McLennan's argument sets out is, therefore, inadmissible.

How inadmissible it is, becomes conspicuous on finding that, where wife-stealing is now practised, it is commonly associated with polygyny. The Fuegians, named by Mr. McLennan among wife-stealing peoples, are polygynists. According to Dove, the Tasmanians were polygynists, and Lloyd says that polygyny was universal among them; yet the Tasmanians were wife-stealers. The Australians furnish Mr. McLennan with a typical instance of wife-stealing and exogamy; and though Mr. Oldfield alleges scarcity of women among them, yet other testimony is quite at variance with his. Mitchell says: "Most of the men appeared to possess two [females], the pair in general consisting of a fat plump gin, and one much younger;" and, according to the Frenchman Peltier, named in the last chapter as having lived seventeen years with the Macadama tribe in Queensland, the women were "more numerous than the men, every man having from two to five women in his suite." In North America the Dakotas are at once wife-stealers and polygynists, Burton tells us. In South America the Brazilians similarly unite these two traits; and among the Caribs they are especially associated. Writing of polygyny as practised on

the Orinoco, Humboldt says: "It is most considerable among the Caribs, and all the nations that have preserved the custom of carrying off young girls from the neighboring tribes." How, then, can wife-stealing be ascribed to scarcity of women?

A converse incongruity also militates against Mr. McLennan's theory. His position is that female infanticide, "rendering women scarce, led at once to polyandry within the tribe, and the capturing of women from without." But polyandry does not, so far as I see, distinguish wife-stealing tribes. We do not find it among the above-named Tasmanians, Australians, Dakotas, Brazilians; and although it is said to occur among the Fuegians, and characterizes some of the Caribs, it is much less marked than their polygyny. Contrariwise, though it is not a trait of peoples who rob one another of their women, it is a trait of certain rude peoples who are habitually peaceful. There is polyandry among the Esquimaux, who do not even know what war is; there is polyandry among the Todas, who in no way aggress upon their neighbors

Other minor difficulties might be dwelt upon. There is the fact that in many cases exogamy and endogamy coexist, as among the Comanches, the New-Zealanders, the Lepchas, the Californians. There is the fact that in sundry cases polygyny and polyandry coexist, as among the Fuegians, the Caribs, the Esquimaux, the Warans, the Hottentots, the ancient Britons. There is the fact that there are some exogamous tribes who have not the form of capture in marriage, as the Iroquois and the Chippewas. But, not dwelling on these, I turn to certain cardinal difficulties, obvious *a priori*, which appear to me insuperable.

Setting out with primitive homogeneous groups, Mr. McLennan contends that the scarcity of women caused by destruction of female infants compelled wife-stealing; and he thinks that this happened "at a certain stage among every race of mankind" (p. 138). The implication is, therefore, that a number of adjacent tribes, usually belonging to the same variety of man in the same stage of progress, were simultaneously thus led to rob one another. But immediately we think of wife-stealing as a practice not of one tribe only, but of many tribes forming a cluster, there presents itself the question, How was the scarcity of women thus remedied? If each tribe had fewer women than men, how could the tribes get wived by robbing one another? The scarcity remained the same: what one tribe got another lost. Bearing in mind the low fertility and great infant mortality among savages, if there is a chronic deficiency of women and the tribes rob one another equally, the result must be diminished population in all the tribes. If some, robbing others in excess, get enough wives, and leave certain of the rest with very few, these must tend toward extinction. And if the surviving tribes carry on the process, there

appears no limit until the strongest tribe, continuing to supply itself with women from the less strong, finally alone survives and has no tribes to rob.

Should it be replied that female infanticide is, on the average of cases, not carried so far as to make the number of wives insufficient to maintain the aggregate population—should it be said that only exceptional tribes rear so few women as not to have mothers enough to produce the next generation—then we are met by a still greater difficulty. If in each of the exogamous tribes forming the supposed cluster the men are forbidden to marry women of their own tribe, and must steal women from other tribes, the implication is that each tribe knowingly rears wives for neighboring tribes, but not for itself. Though each tribe kills many of its female infants that it may not be at the cost of rearing them for its own benefit, yet it deliberately rears the remainder for the benefit of its enemies. Surely this is an inadmissible supposition. In proportion as the interdict against marrying women within the tribe is peremptory, the preservation of girls will be useless — worse than useless, indeed, since adjacent hostile tribes, to whom they must go as wives, will be thereby strengthened. And as all the tribes, living under like interdicts, will have like motives, they will all of them cease to rear female infants.

Manifestly, then, exogamy in its original form can never have been anything like absolute among the tribes forming a cluster, but can have been the law among some of them only.

In his concluding chapter Mr. McLennan says that, "on the whole, the account which we have given of the origin of exogamy appears the only one which will bear examination" (p. 289). It seems to me, however, that setting out with the postulate laid down by him, that primitive groups of men are habitually hostile, we may, on asking what are the concomitants of war, be led to a different theory, open to none of the objections above raised.

In all times and places, among savage and civilized, victory is followed by pillage. Whatever portable things of worth the conquerors find, they take. The enemies of the Fuegians plunder them of their dogs and arms; pastoral tribes in Africa have their cattle driven away by conquering marauders; and peoples more advanced are robbed of their money, ornaments, and all valuable things that are not too heavy. The taking of women is manifestly but a part of this process of spoiling the vanquished. Women are prized as wives, as concubines, as drudges; and, the men having been killed, the women are carried off along with the other movables. Everywhere among the uncivilized we find this. Turner tells us that "in Samoa, in dividing the spoil of a conquered people, the women were not killed, but taken as wives." We learn from Mitchell that in Australia, "on some whites telling a native that they had shot a man of another tribe, his only remark

was: 'Stupid white fellows! why did you not bring away the gins?'" And P. Martyr says that among the cannibal Caribs in his day "to eat women was considered unlawful. . . . Those who were captured young were kept for breeding, as we keep fowl, etc." Early legends of the semi-civilized show us the same thing; as when in the "Iliad" we read that the Greeks plundered "the sacred city of Eëtion," and that part of the spoils "they divided among themselves" were the women. And there need no examples to recall the fact that in later and more civilized times successes in battle have been followed by transactions allied in character, if not the same in form. Hence it is obvious that, from the beginning down to comparatively late stages, women-stealing has been an *incident* of successful war.

Observe, next, that the spoils of conquest, some of them prized for themselves, are some of them prized as trophies. Proofs of prowess are above all things treasured by the savage. He brings back his enemy's scalp, like the North American Indian. He dries and preserves his enemy's head, like the New-Zealander. He fringes his robe with locks of hair cut from his slain foe. Among other signs of success in battle is return with a woman of the vanquished tribe. Beyond her intrinsic value she has an extrinsic value. Like a native wife, she serves as a slave; but, unlike a native wife, she serves also as a trophy. As, then, among savages, warriors are the honored members of the tribe—as among warriors the most honored are those whose bravery is best shown by achievements—the possession of a wife taken in war becomes a badge of social distinction. Hence members of the tribe thus married to foreign women are held to be more honorably married than those married to native women. What must result?

In a tribe not habitually at war, or not habitually successful in war, no decided effect is likely to be produced on the marriage customs. If the great majority of the men have native wives, the presence of a few whose superiority is shown by having foreign wives will fail to change the practice of taking native wives: the majority will keep one another in countenance. But if the tribe, becoming more successful in war, robs adjacent tribes of their women more frequently, there will grow up the idea that the now-considerable class having foreign wives form the honorable class, and that those who have not proved their bravery by bringing back these living trophies are dishonorable: non-possession of a foreign wife will come to be regarded as a proof of cowardice. An increasing ambition to get foreign wives will therefore arise; and as the number of those who are without them decreases, the brand of disgrace attaching to them will grow more decided; until, in the most warlike tribes, it becomes an imperative requirement that a wife shall be obtained from another tribe—if not in open war, then by private abduction.

A few facts showing that by savages proofs of courage are often

required as qualifications for marriage, will carry home this conclusion. Herndon tells us that among the Mahués a man cannot take a wife until he has submitted to severe torture. Bates, speaking of the Passés on the Upper Amazons, says that formerly "the young men earned their brides by valiant deeds in war." Before he is allowed to marry, a young Dyak must prove his bravery by bringing back the head of an enemy. Bancroft quotes Colonel Cremony as saying that when the Apache warriors return unsuccessful, "the women turn away from them with assured indifference and contempt. They are upbraided as cowards, or for want of skill and tact, and are told that such men should not have wives." That, among other results of sentiments thus exemplified, abduction of women will be one, is obvious; for a man who, denied a wife till he has proved his courage, steals one, satisfies his want and achieves reputation at the same time. If, as we see, the test of deserving a wife is in some cases obtainment of a trophy, what more natural than that the trophy should often be the stolen wife herself? What more natural than that where many warriors of the tribe are distinguished by stolen wives, the stealing of a wife should become the required proof of fitness to have one? Hence would follow a peremptory law of exogamy.

In so far as it implies that usage grows into law, this interpretation agrees with that of Mr. McLennan. It does not, however, like his, assume either that this usage originated in a primordial instinct, or that it resulted from scarcity of women caused by infanticide. Moreover, unlike Mr. McLennan's, the explanation so reached is consistent with the fact that exogamy and endogamy in many cases exist; and with the fact that exogamy often coexists with polygyny. Further, it does not involve us in the difficulty raised by supposing a peremptory law of exogamy to be obeyed throughout a cluster of tribes.

But can the great prevalence of the form of capture in marriage ceremonies be thus accounted for? Mr. McLennan believes that, wherever this form is now found, complete exogamy once prevailed. Examination will, I think, show that the implication is not necessary. There are several ways in which the form of capture naturally arises; or rather, let us say, it has several conspiring causes.

If, as we have seen, there still exist rude tribes in which men fight for possession of women, the taking possession of a woman naturally comes as a sequence to an act of capture. That monopoly which constitutes her a wife in the only sense known by the primitive man is a result of successful violence. Thus the form may originate from actual capture within the tribe instead of originating from actual capture without it.

Beyond that resistance to a man's seizure of a woman apt to be made by other men within the tribe, there is the resistance of the

woman herself. Sir John Lubbock expresses the opinion that female coyness is not an adequate cause for the establishment of the form of capture; and it may be that, taken alone, it does not suffice to account for everything. But there are reasons for thinking it an important factor. Here are some of them. Crantz tells us concerning the Esquimaux that, when a damsel is asked in marriage, she—

"directly falls into the greatest apparent consternation, and runs out-of-doors tearing her bunch of hair; for single women always affect the utmost bashfulness and aversion to any proposal of marriage, lest they should lose their reputation for modesty."

Like behavior is shown by Bushmen girls. When—

"a girl has grown up to womanhood without having previously been betrothed, her lover must gain her own approbation, as well as that of the parents; and on this occasion his attentions are received with an affectation of great alarm and disinclination on her part, and with some squabbling on the part of her friends."

Again, among the Sinai Arabs, says Burckhardt, a bride—

"defends herself with stones, and often inflicts wounds on the young men, even though she does not dislike the lover; for, according to custom, the more she struggles, bites, kicks, cries, and strikes, the more she is applauded ever after by her own companions." During the procession to the husband's camp, "decency obliges her to cry and sob most bitterly."

Of the Muzos, Piedrahita narrates that after agreement with the parents was made—

"the bridegroom came to see the bride, and staid three days caressing her, while she replied by beating him with her fists and with sticks. After these three days she got tamer, and cooked his meals."

In these cases, then, coyness, either real or affected for reputation's sake, causes resistance of the woman herself. In other cases there is joined with this the resistance of her female friends. We read of the Sumatran women that "both the bride and her female relatives make it a point of honor to prevent (or appear to prevent) the bridegroom from obtaining his bride." On the occasion of a marriage among the Araucanians, Smith tells us that "the women spring up *en masse*, and arming themselves with clubs, stones, and missiles of all kinds, rush to the defense of the distressed maiden. . . . It is a point of honor with the bride to resist and struggle, however willing she may be." And once more we learn from Grieve that when a Kamtchatkan "bridegroom obtains the liberty of seizing his bride, he seeks every opportunity of finding her alone, or in company of a few people, for during this time all the women in the village are obliged to protect her."

Here we have, I think, proof that one origin of the form of capture is feminine opposition—primarily of the woman herself, and secondarily of female friends who naturally sympathize with her. Though the manners of the inferior races do not imply much coyness, yet we

cannot suppose coyness to be wholly absent. Hence that amount of it which really exists, joined with that further amount simulated for reputation's sake, will make resistance, and consequently capture, natural phenomena. Moreover, since a savage makes his wife a slave, and usually treats her brutally, she has an additional motive for resistance.

Nor does forcible opposition proceed only from the girl and her female friends: the male members of her family also are likely to be opponents. A woman is of value not only as a wife, but also as a daughter; and all through, from the lowest to the highest stages of social progress, we find a tacit or avowed claim to her services by her father. It is so even with the degraded Fuegians: an equivalent in the shape of service rendered has to be given for her by the youth, "such as helping to make a canoe." It is so with numerous more advanced savages all over the world: there is either the like giving of stipulated work, or the giving of a price. And we have evidence that it was originally so among ourselves: in an action for seduction the deprivation of a daughter's services is the injury alleged. Hence it is inferable that in the rudest states, where claims, parental or other, are but little regarded, the taking away of a daughter is likely to become the occasion of a fight. Facts support this conclusion. Of the Araucanians Smith tells us that, when there is opposition of the parents, "the neighbors are immediately summoned by blowing the horn, and chase is given." "Among the Gándors, a tribe on the southern shores of the Caspian Sea, the bridegroom must run away with his bride, although he thereby exposes himself to the vengeance of her parents, who, if they find him within three days, can lawfully put him to death." And we read concerning the Gonds that "a suitor usually carries off the girl that is refused to him by the parents." Thus we find a further natural cause for the practice of capture—a cause which must have been common before social usages were well established. Indeed, on reading that among the Mapuchés the man sometimes "lays violent hands upon the damsel, and carries her off," and that "in all such cases the usual equivalent is afterward paid to the girl's father," we may suspect that abduction, spite of parents, was the primary form; that there came next the making of compensation to escape vengeance; that this grew into the making of presents beforehand; and that so resulted eventually the system of purchase.

If, then, within a tribe there are three sources of opposition to the appropriation of a woman by a man, it does not seem that the form of capture is inexplicable unless we assume the abduction of women from other tribes.

But even supposing it to have originated in the capture of foreign women, its survival as a form of marriage would not prove exogamy to have been the law. In a tribe whose warriors had many of them wives taken from enemies, and who, as having captured their wives,

were regarded as more honorably married than the rest, there would result an ambition, if not to capture a wife, still to seem to capture a wife. In every society the inferior ape the superior; and customs thus spread among classes, the ancestors of which did not observe them. The antique-looking portraits that decorate many a modern, large house, by no means demonstrate the distinguished ancestry of the owner; but may merely simulate a distinguished ancestry. The coat of arms a wealthy man bears does not necessarily imply descent from men who once had their shields and flags covered by such marks of identity. The plumes borne on a hearse do not prove that the dead occupant had forefathers who wore knightly decorations. And, similarly, it does not follow that all the members of tribes who go through the form of capturing their wives at marriage are descendants of men who in earlier days actually captured their wives. Mr. McLennan himself points out that, among sundry ancient peoples, captured wives were permitted to the military class, though not to other classes. If we suppose a society formed of a dominant military class, originally the conquerors, who practised wife-capture, and a subject class who could not practise it—and if we ask what would happen when such a society fell into more peaceful relations with adjacent like societies, and obtained wives from them no longer by force, but by purchase or other friendly arrangement—we may see that, in the first place, the form of capture would replace the actuality of capture in the marriages of this dominant class; for, as Mr. McLennan contends, conformity to ancestral usage would necessitate the simulation of capture after actual capture has ceased. And when, in the dominant class, wife-capture had thus passed into a form, it would be imitated by the subject class as being the most honorable form. Such among the inferior as had risen to superior social positions would first adopt it; and they would gradually be followed by those below them. So that, even were there none of the other probable origins named above, a surviving form of capture in any society would not necessarily show that society to have been exogamous, but would merely show that wife-capture was in early times practised by its leading men.

And now, pursuing the argument, let us see whether exogamy and endogamy are not simultaneously accounted for as correlative results of the same differentiating process. Setting out with a state in which the relations of the sexes were indefinite, variable, and determined by the passions and circumstances of the occasion, we have to explain how exogamy and endogamy became established, the one here, the other there, as consequences of surrounding conditions. The efficient conditions were the relations to other tribes, now peaceful but mostly hostile, some of them strong, and some of them weak.

Necessarily, a primitive group not commonly at war with neighboring groups must be endogamous; for the taking of women from

other tribes is either a sequence of open war, or is an act of private war which brings on open war. Pure endogamy, however, resulting in this manner, is probably rare, since the hostility of tribes is almost universal. But endogamy is likely to characterize not peaceful groups alone, but also groups habitually worsted in war. An occasional abducted woman taken in reprisal will not suffice to establish in a weak tribe any precedent for wife-capture; but, contrariwise, a member of such a tribe who carries off a woman, and so provokes vengeance by the stronger tribe robbed, is likely to meet with general reprobation.[1] Hence marrying in the tribe will not only be habitual, but there will arise a prejudice, and eventually a law, against taking wives from other tribes; the needs of self-preservation will make the tribe endogamous. This interpretation harmonizes with the fact, admitted by Mr. McLennan, that the endogamous tribes are as numerous as the exogamous; and also with the fact he admits, that in sundry cases clusters of tribes allied by blood and language are some of them exogamous and some endogamous.

It is to be inferred that, among tribes not differing much from one another in strength, there will be continual aggressions and reprisals, accompanied by mutual robberies of women. No one of them will be able to supply itself with wives entirely at the expense of adjacent tribes, and hence, in each of them, there will be both native wives, and wives taken from other tribes—there will be both exogamy and endogamy. Stealing of wives will not be reprobated, because the tribes robbed are not too strong to be defied; and it will not be insisted on, because the men who have stolen wives will not be numerous enough to determine the average opinion.

If, however, in a cluster of tribes, one gains predominance by frequent successes in war—if the men in it who have stolen wives come to form the larger number—if the possession of a stolen wife becomes a mark of that bravery without which a man is not worthy of a wife—then the discreditableness of marrying within the tribe, growing into disgracefulness, will end in a peremptory requirement to get a wife from another tribe—if not in open war, then by private theft: the tribe will become exogamous. A sequence may be traced. The exogamous tribe thus arising, and growing while it causes adjacent tribes to dwindle by robbing them, will presently divide; and its sections, usurping the habitats of adjacent tribes, will carry with them the established exogamous habit. When, presently becoming hostile, these diverging sub-tribes begin to rob one another of women, there will

[1] Since the above sentence was written, I have, by a happy coincidence, come upon a verifying fact, in the just-published "Life in the Southern Isles," by the Rev. Mr. Gill (p. 47). A man, belonging to one of the tribes in Mangaia, stole food from an adjacent tribe. This adjacent tribe avenged itself by destroying the houses, etc., of the thief's tribe. Thereupon the thief's tribe, angry because of the mischief thus brought upon them, killed the thief. If this happened with a stealer of food, still more would it be likely to happen with a stealer of women, when the tribe robbed was the more powerful.

arise conditions conducive to that internal exogamy which Mr. McLennan supposes, rightly I think, to replace external exogamy. For, unless we assume that, in a cluster of tribes, each will undertake to rear women for adjacent tribes to steal, we must conclude that the exogamous requirement will be met in a qualified manner. Wives born within the tribe, but foreign by blood, will, under pressure of the difficulty, be considered allowable, instead of actually stolen wives. And thus, indeed, that kinship in the female line, which primitive irregularity in the relations of the sexes originates, will become established, even though male parenthood is known; since this interpretation of kinship will make possible conformity to a law of *connubium* that could not otherwise be obeyed.

Nothing of much importance is to be said respecting exogamy and endogamy in their general bearings on social life.

Exogamy in its primitive form is clearly an accompaniment of the lowest barbarism; and it decreases as the hostility of societies becomes less constant, and the usages of war mitigated. That the implied crossing of tribal stocks, where these tribal stocks are very small, may be advantageous, physiologically, is true; and exogamy may so secure a benefit which at a later stage is secured by the mingling of conquering and conquered tribes; though none who bear in mind the thoughtlessness of savages will suppose such a benefit to have been contemplated. But the exogamous custom, as at first established, implies an extremely abject condition of women; a brutal treatment of them; an entire absence of the higher sentiments that accompany the relation of the sexes. Associated with the lowest type of political life, it is also associated with the lowest type of domestic life.

Evidently endogamy, which at the outset must have characterized the more peaceful groups, and which has prevailed as societies have become less hostile, is a concomitant of the higher forms of the family.

PROFESSOR HUXLEY'S LECTURES.[1]

III.

THE DEMONSTRATIVE EVIDENCE OF EVOLUTION.

IN my last lecture, I had occasion to place before you evidence derived from fossil remains, which, as I stated, was perfectly consistent with the doctrine of evolution, in fact, was favorable to it, but could not be regarded as the highest kind of evidence, or as that sort of evidence that we call demonstrative.

[1] The last of three lectures on "The Direct Evidence of Evolution," delivered at Chickering Hall, New York, September 20th. From the report of the *New York Tribune*, carefully revised by Prof. Huxley.

I pointed out, in fact, that, as we go back in time, the great intervals which at present separate some of the larger divisions of animals become more or less completely obliterated by the appearance of intermediate forms, so that if we take the particular case of reptiles and birds, upon which I dwelt at length, we find in the mesozoic rocks animals which, if ranged in series, would so completely bridge over the interval between the reptile and the bird that it would be very hard to say where the reptile ends and where the bird begins. Evidence so distinctly favorable to evolution as this is far weightier than that upon which men undertake to say that they believe many important propositions; but it is not the highest kind of evidence attainable for this reason, that, as it happens, the intermediate forms to which I have referred do not occur in the exact order in which they ought to occur, if they really had formed steps in the progression from the reptile to the bird; that is to say, we find these forms in contemporaneous deposits, whereas the requirements of the demonstrative evidence of evolution demand that we should find the series of gradations between one group of animals and another in such order as they must have followed if they had constituted a succession of stages, in time, of the development of the form at which they ultimately arrive. In other words, the complete evidence of the evolution of the bird from the reptile—what I call the demonstrative evidence, because it is the highest form of this class of evidence; that evidence should be of this character, that in some ancient formation reptiles alone should be found; in some later formations birds should first be met with; and in the intermediate strata we should discover in regular succession those forms which I pointed out to you which are intermediate between reptiles and birds.

The proof of evolution cannot be complete until we have obtained evidence of this character, and that evidence has of late years been forthcoming in considerable and continually increasing quantity. Indeed, it is somewhat surprising how large is the quantity of that evidence, and how satisfactory is its nature, if we consider that our obtaining such evidence depends upon the occurrence in a particular locality of an undisturbed series deposited through a long period of time, which requires the further condition that each of these deposits should be such that the animal remains imbedded in them are not much disturbed, and are imbedded in a state of great preservation. Evidence of this kind, as I have said, has of late years been accumulating largely, and in respect to many divisions of the animal kingdom. But I will select for my present purpose only one particular case, which is more adapted to the object I have in view, as it relates to the origin, to what we may call the pedigree, of one of our most familiar domestic animals—the horse. But I may say that in speaking of the origin of the horse I shall use that term in a general sense as equivalent to the technical term *Equus*, and meaning not what you

ordinarily understand as such, but also asses and their modifications, zebras, etc. The horse is in many ways a most remarkable animal, inasmuch as it presents us with an example of one of the most perfect pieces of machinery in the animal kingdom. In fact, among mammals it cannot be said that there is any locomotive so perfectly adapted to its purposes, doing so much work with so small a quantity of fuel, as this animal—the horse. And, as a necessary consequence of any sort of perfection, of mechanical perfection as of others, you find that the horse is a beautiful creature, one of the most beautiful of all land-animals. Look at the perfect balance of its form, and the rhythm and perfection of its action. The locomotive apparatus is, as you are aware, resident in its slender fore and hind limbs; they are flexible and elastic levers, capable of being moved by very powerful muscles; and, in order to supply the engines which work these levers with the force which they expend, the horse is provided with a very perfect feeding apparatus, a very perfect digestive apparatus.

Without attempting to take you very far into the region of osteological detail, I must nevertheless—for this question depends upon the comparison of such details—trouble you with some points respecting the anatomical structure of the horse, and more especially with those which refer to the structure of its fore and hind limbs. But I shall only touch upon those points which are absolutely essential to the inquiry that we have at present put. Here is the fore-leg of a horse: The bone which is cut across at this point is that which answers to the upper-arm bone in my arm, what you would call the humerus. This bone corresponds with my forearm. What we commonly term the knee of the horse is the wrist; it answers to the wrist in man. This part of the horse's leg answers to one of the human fingers, and the hoof which covers this extended joint answers to one of my nails.

You observe that, to all appearance, there is only one bone in the forearm. Nevertheless, at the upper end I can trace two separate portions; this part of the limb, and the one I am now touching. But as I go farther down it runs at the back part into the general bone, and I cease to be able to trace it beyond a certain point. This large bone is what is termed the radius, and answers to the bone I am touching in my arm, and this other portion of bone corresponds to what is called the ulna. To all appearance in the forearm of the horse the ulna is rudimentary, and seems to be fused into one bone with the radius.

It looks thus as if the ulna, running off below, came to an end, and it very often happens in works on the anatomy of the horse that you find these facts are referred to, and a horse is said to have an imperfect ulna. But a careful examination shows you that the lower extremity of the ulna is not wanting in the horse. If you examine a very young horse's limb you will find that this portion of the bone I

am now showing you is separable from the rest, and only unites as the animal becomes older, and this is, in point of fact, the lower extremity of the ulna; so that we may say that in the horse the middle part of the ulna becomes rudimentary and unites with the radius, and that the lower extremity of the ulna is so early united with the lower extremity of the radius that every distinct trace of separation has vanished in the adult.

I need not trouble you with the structure of this portion that answers to the wrist, nor with a more full description of the singular peculiarities of the part, because we can do without them for the present, but I will go on to a consideration of the remarkable series of bones which terminates the fore-limb. We have one continuous series in the middle line which terminates in the coffin-bone of the horse upon which the weight of the fore-part of the body is supported. This series answers to a finger of my hand, and there are good reasons—perfectly valid and convincing reasons, which I need not stay to trouble you with—which prove that this answers to the third finger of my hand enormously enlarged.

And it looks at first as if there were only this one finger in the horse's foot. But, if I turn the skeleton round, I find on each side a bone shaped like a splint, broad at the upper and narrow at the lower end, one on each side. And those bones are obviously and plainly and can be readily shown to be the rudiments of the bones which I am now touching in my own hand—the metacarpal bones of the second and of the fourth finger—so that we may say that in the horse's fore-limb the radius and ulna are fused together, that the middle part of the ulna is excessively narrow, and that the foot is reduced to the single middle finger, with rudiments of the two other fingers, one on each side of it. Those facts are represented in the diagram I now show you of the recent horse. Here is the fore-limb (pointing to the diagram), with the metacarpal bones and the little splint-bones, one on each side. It sometimes happens that by way of a monstrosity you may have an existing horse with one or other of these toes—that is, provided with its terminal joints.

Let me now point out to you what are the characteristics of the hind-limb. This (pointing to the diagram) is the shin-bone of the horse, and it appears at first to constitute the whole of the leg. But there is a little splint at this point which is the rudiment of the small bone of the leg—what is called the fibula—and then there is connected with the lower end of the tibia a little nodule which represents the lower end of the fibula, in just the same way as that little nodule in the fore-limb represents the lower end of the ulna. So that in the leg we have a modification of the same character as that which exists in the fore-limb—the suppression of the greater part of the small bone of the leg and the union of its lower end with the tibia. So, again, we find the same thing if we turn to the remainder of the leg.

This (showing) is the heel of the horse, and here is the great median toe, answering to the third toe in our own foot; and here we have upon each side two little splint-bones, just as in the fore-limb, which represent the rudiments of the second and the fourth toes—rudiments, that is to say, of the metatarsal bones, the remaining bones having altogether vanished. Let me beg your attention to these peculiarities, because I shall have to refer to them by-and-by. The result of this modification is, that the fore and hind limbs are converted into long, solid, springy, elastic levers, which are the great instruments of locomotion of the horse.

As might be expected, and as I have already said, the apparatus for providing this machine with the fuel which it requires is also of a very highly differentiated character. A horse has, or rather may have, forty-four teeth, but it rarely happens that in our existing horses you find more than forty—for a reason which I will communicate directly—and in a mare it commonly happens that you find no more than thirty-six, because the "tushes," or canine teeth, of the mare are rarely developed. Then there are some curious peculiarities about these teeth. As every one who has had to do with horses knows, the cutting teeth—the incisors—are six above and six below, and those incisors present what is called a "mark;" at least, that mark is usually present in horses up to a certain age. It is a sort of dark patch across the middle of the tooth. The presence of that dark patch arises from a great peculiarity in the structure of the horse's incisor tooth. It is in fact considerably curved, with a deep pit in the middle of the crown, and then a long fang. In the young foal this pit is very deep. As the animal feeds, this pit becomes filled up with its fodder, that fodder becomes more or less carbonized, and then you have the dark mark, and the reason the dark mark serves as an indication of age, for, as the horse feeds, this is more and more worn down, until at last, in an aged horse, the tooth is worn beyond the bottom of the pit, and the mark disappears. Then, as I said, the male horse generally has canine teeth. We need not notice their structure particularly. Following that, you may occasionally notice a very small and rudimentary tooth, but it is very often absent. It really represents the first tooth of the grinding series. Then there follow six great teeth, with exceedingly long crowns. The crowns, in fact, are so long that the teeth take a very long time to wear down, whence arises the possibility of the great age to which horses sometimes attain. This is shown in the side diagram. Then the pattern and structure of a horse's tooth are very curious. The crown of the horse's tooth presents a very complicated pattern; that is to say, supposing this to be one of the grinders of the left side (illustrating) above, there is a kind of wall like a double crescent. Then there are two other crescents, which fall in that direction, and these are complicated by folds, and all the spaces between these crescentic ridges are filled up by a kind

of bony matter which is called cement. Consequently the surface of the tooth is composed of very uneven materials—of the hard mass of the tooth, which is called dentine, then a very much harder enamel, and a softer cement between, the practical effect of which is the same as the lamination of the millstone. In consequence of the lamination of the millstone the ridges wear less swiftly than the intermediate substance, and therefore the surface always keeps rough and exerts a crushing effect upon the grain. The same is true of the horse's tooth, and consequently the grinding of the teeth one against the other, instead of flattening the surface of the teeth, tends to keep them always irregular, and that has a very great influence upon the rapid mastication of the hard grain or the hay upon which the horse subsists.

I think that will suffice as a brief indication of some of the most important peculiarities and characteristics of the horse. If the hypothesis of evolution is true, what ought to happen when we investigate the history of this animal? We know that the mammalian type, as a whole—that mammalian animals—are characterized by the possession of a perfectly distinct radius and ulna, two separate and distinct movable bones. We know, further, that mammals in general possess five toes, often unequal, but still as completely developed as the five digits of my hand. We know further that the general type of mammal possesses in the leg, not only a complete tibia, but a complete fibula—a complete, distinct, separable bone. Moreover, in the hind-foot we find, in animals in general, five distinct toes, just as we do in the fore-foot. Hence it follows a differentiated animal like the horse must have proceeded by way of evolution or gradual modification from a form possessing all the characteristics we find in mammals in general. If that be true, it follows that if there be anywhere preserved in the series of rocks a complete history of the horse, that is to say of the various stages through which he has passed, those stages ought gradually to lead us back to some sort of animal which possessed a radius, and an ulna, and distinct complete tibia and fibula, and in which there were five toes upon the fore-limb, no less than upon the hind-limb. Moreover, in the average general mammalian type, the higher mammalian, we find, as a constant rule, an approximation to the number of forty-four complete teeth, of which twelve are cutting teeth, four are canine, and the others are grinders. In unmodified mammals we find the incisors have no pit, and that the grinding teeth, as a rule, increase in size from that which lies in front toward those which lie in the middle or at the hinder part of the series. Consequently, if the theory of evolution be correct, if that hypothesis of the origin of living things have a foundation, we ought to find in the series the forms which have preceded the horse, animals in which the mark upon the incisor gradually more and more disappears, animals in which the canine teeth are present in both sexes, and ani-

mals in which the teeth gradually lose the complications of their crowns and have a simpler and shorter crown, while at the same time they gradually increase in size from the anterior end of the series toward the posterior. Let us turn to the facts and see how they bear upon the requirements of this doctrine of evolution.

In what is called here the Pliocene formation, that which constitutes almost the uppermost division of the tertiary series, we find the remains of horses. We also find in Europe abundant remains of horses in the most superficial of all these formations—that is, the post-tertiary, which immediately lies above the Pliocene. But these horses, which are abundant in the cave-deposits and in the gravels of England and Europe—these horses, of which we know the anatomical structure to perfection—are in all essential respects like existing horses. And that is true of all the horses of the latter part of the Pliocene epoch. But in the earlier Pliocene and later Miocene epoch, in deposits which belong to that age, and which occur in Germany and in Greece, in India, in Britain, and in France, we find animals which are like horses in all the essential particulars which I have just described, and the general character of which is so entirely like that of the horse that you may follow descriptions given in works upon the anatomy of the horse upon the skeletons of these animals. But they differ in some important particulars. There is a difference in the structure of the fore and hind limb, and that difference consists in this, that the bones which are here represented by two splints, imperfect below, are as long as the middle metacarpal bone, and that attached to the extremity of each is a small toe with its three joints of the same general character as the middle toe, only very much smaller, and so disposed that they could have had but very little functional importance, and that they must have been rather of the nature of the dew-claws such as are to be found in many ruminant animals. This *Hipparion*, or European three-toed horse, in fact presents a foot similar to that which you see here represented, except that in the European *Hipparion* these smaller fingers are farther back, and these lateral toes are of smaller proportional size.

But nevertheless we have here a horse in which the lateral toes, almost abortive in the existing horse, are fully developed. On careful investigation you find in these animals that also in the fore-limb the ulna is very thin, yet is traceable down to the extremity. In the hind-limb you find that the fibula is pretty much as in the existing horse. That is the kind of equine animal which you meet with in these older Pliocene and later Miocene formations, in which the modern horse is no longer met with. So you see that the *Hipparion* is the form that immediately preceded the horse. Now let us go a step farther back to the middle and older parts of which are called the Miocene formation. There you find in some parts of Europe the equine animals which differ essentially from the modern horse, though

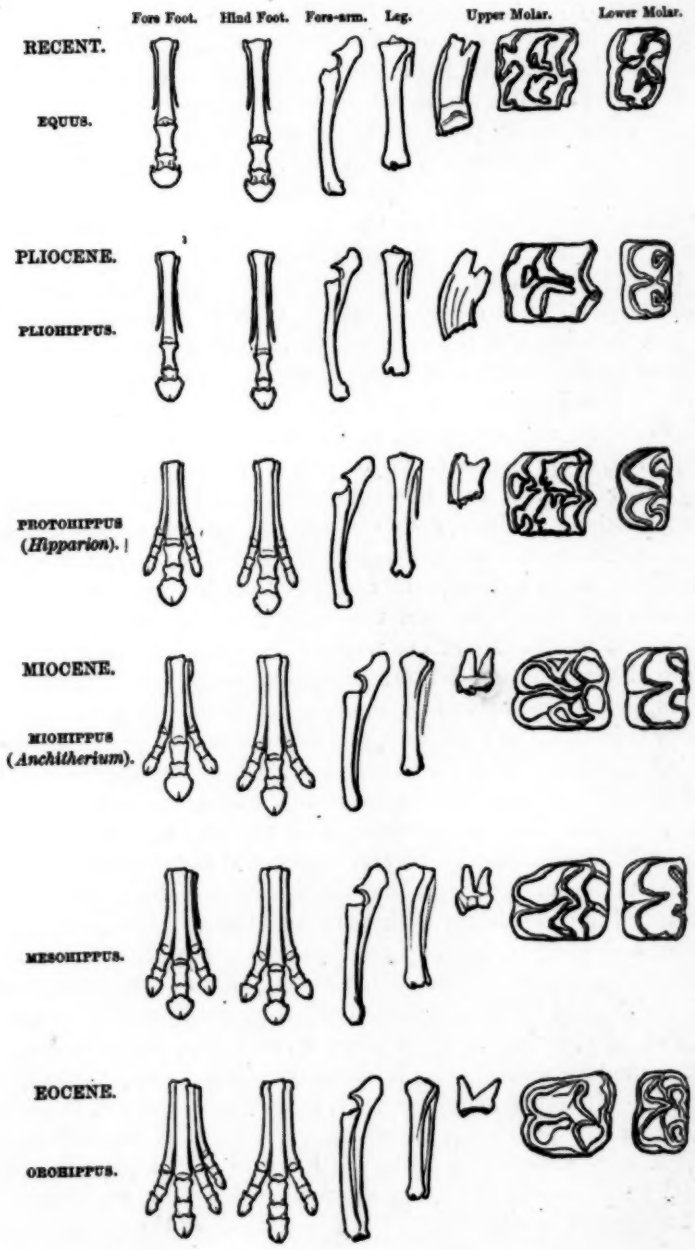
they resemble the horse in the broad features of their organization. They differ in the characters of their fore and hind limbs, and present important features of difference in the teeth. The forms to which I now refer are what constitute the genus *Anchitherium*. We have three complete toes; the middle toe is smaller in proportion, the inner and outer toes are larger, and in fact large enough to rest upon the ground, and to have functional importance—not an animal with two dew-claws, but an animal with three functional toes. And in the fore-arm you find the ulna a very distinct bone, quite readily distinguishable in its whole length from the radius, but still pretty closely united with it. In the hind-limb you also meet with three functional toes. The structure of the hind-foot corresponds with that of the fore-foot; but in the hind-leg the fibula is better developed. In some cases I have reason to think that it is complete; at any rate this lower end of it is quite distinctly recognizable. But the most curious change is that which is to be found in the character of the teeth. The teeth of the *Anchitherium* have, in the first place, so far as the incisors are concerned, a rudimentary pit. The canine teeth are present in both sexes. The molars are short; there is no cement, and the pattern is somewhat like this (drawing on the blackboard). In the upper jaw, there are two crescents and two oblique ridges, while in the lower jaw you have the double crescent. It is quite obvious that this (illustrating from drawing) is a simpler form than that. By increasing the complexity of those teeth there, we have the horse's teeth. These are all the forms with which we are acquainted respecting the past history of the horse in Europe. When I happened to occupy myself with this subject some years ago, notwithstanding certain difficulties, the facts left no doubt whatever in my mind that we had here a general record of the history of the evolution of the horse. You must understand that every one of these forms has undoubtedly become modified into various species, and we cannot be absolutely certain that we have found those species which constitute the exact line of modification, but it was perfectly obvious that we had here in succession, in time, three forms of the horse-type, of which the oldest came nearest to the general mammal. We saw that the forms which had existed afterward had undergone a reduction of the number of their toes, a reduction of the fibula, a more complete coalescence of the ulna with the radius. The pattern of the molar teeth had become more complicated and the interspaces of their ridges had become filled with cement. In this succession of forms you have exactly that which the hypothesis of evolution demands. The history corresponds exactly with that which you would construct *a priori* from the principles of evolution. An alternative hypothesis is hardly conceivable, but the only one that could be framed would be this, that the *Anchitherium*, the *Hipparion*, and the horse, had been created separately and at separate epochs of time. For that hypothesis there could be

no scientific evidence, and it is not pretended that there is the slightest evidence of any other kind that such successive creation has ever taken place. When I was investigating this subject only the collections in Europe were accessible to me, but the materials they yielded led me to think that the horse must have descended from an *Anchitherium*-like ancestor, and I may say, as I happen to know by correspondence with him, that very eminent anatomist, the late Prof. Lartet, of Paris, had arrived independently at the same conclusion. Indeed, the story is so plain that no one deserves any particular credit for drawing so obvious a conclusion. And since then paleontological inquiry has not only given us greater and greater knowledge of the series of horse-like forms, but enabled us to fill up the gaps in the series, and to extend that series farther back in time.

That knowledge has recently come to us, and assuredly from a most unexpected quarter. You are all aware that when this country was first discovered by Europeans there were no traces of the existence of the horse in any part of the American Continent. And, as is well known, the accounts of the earlier discoveries dwell upon the astonishment of the natives when they first became acquainted with that astounding phenomenon—a man seated upon a horse. Nevertheless, as soon as geology began to be pursued in this country, it was found that remains of horses—horses like our European horses—like the horses which exist at the present day—are to be found in abundance in the most superficial deposits in this country, just as they are in Europe. For some reason or other—no feasible suggestion on that subject, so far as I know, has been made—but for some reason or other the horse must have died out on this continent at some period preceding—how long we cannot say—the discovery of America by the Europeans. Of late years there have been discovered on this continent—in your Western Territories—that marvelous thickness of tertiary deposits to which I referred the other evening, which gives us a thickness and a consecutive order of older tertiary rocks admirably calculated for the preservation of organic remains, such as we had hitherto no conception of in Europe. They have yielded fossils in a state of preservation and in number perfectly unexampled. And with respect to the horse, the researches of Leidy and others have shown that numerous forms of that type are to be found among these remains. But it is only recently that the very admirably contrived and most thoroughly and patiently worked-out investigations of Prof. Marsh have given us a just idea of the enormous wealth and scientific importance of these deposits. I have had the advantage of glancing over his collections at New Haven, and I can truly and emphatically say that, so far as my knowledge extends, there is nothing in any way comparable, for extent, or for the care with which the remains have been got together, or for their scientific importance, to the series of fossils which he has brought together. (Applause.) This enormous

collection has yielded evidence of the most striking character in regard to this question of the pedigree of the horse. Indeed, the evidence which Prof. Marsh has collected tends to show that you have in America the true original seat of the equine type—the country in which the evidence of the primitive form and successive modifications of the horse series is far better preserved than in Europe; and Prof. Marsh's kindness has enabled me to put before you the following diagram, every figure in which is an actual representation of the specimen which is preserved in New Haven at this present time. The succession of forms which he has brought together shows, in the first place, the great care and patience to which I have referred. Secondly, there is this Pliocene form of the horse (*Pliohippus*); the conformation of its limbs presents some very slight deviations from the ordinary horse, and with shorter crown of the grinding teeth. Then comes the form which represents the European *Hipparion*, which is the *Protohippus*, having three toes and the forearm and leg and teeth to which I have referred, and which is more valuable than the European *Hipparion* for this reason: it is devoid of some of the peculiarities of that form—peculiarities which tend to show that the European *Hipparion* is rather a side branch than one in the direct line of succession. Next comes the *Miohippus*, which corresponds pretty nearly with what I spoke of as the *Anchitherium* of Europe, but which has some interesting peculiarities. It presents three toes—one large median and two lateral ones; of the toe which answers to the little finger of the human hand, there is only a rudiment. This is, however, as far as European deposits have been enabled to carry us with any degree of certainty in the history of the horse. In the American tertiaries, on the contrary, the series of equine forms is continued down to the bottom of the Eocene. The older Miocene form, termed *Mesohippus*, has three toes in front and a large splint-like rudiment representing the little finger, and three toes behind. The radius and ulna are entire, and the tibia and fibula distinct, and the teeth are anchitheroid with short crowns.

But the most important discovery of all is the *Orohippus*—which comes from the lower part of the Eocene formation, and is the oldest member of the equine series known. Here we have four complete toes on the front-limb, three toes on the hind-limb, a well-developed ulna, a well-developed fibula, and the teeth of simple pattern. So you are able, thanks to these great researches, to show that, so far as present knowledge extends, the history of the horse-type is exactly and precisely that which could have been predicted from a knowledge of the principles of evolution. And the knowledge we now possess justifies us completely in the anticipation that when the still lower Eocene deposits and those which belong to the Cretaceous epoch have yielded up their remains of equine animals, we shall find first an equine creature with four complete toes and a rudiment of the innermost toe in front, and probably a rudiment of the fifth toe in the


Fore Foot.
Hind Foot.
Fore-arm.
Leg.
Upper Molar.
Lower Molar.
RECENT.
EQUUS.
PLIOCENE.
PLIOHIPPUS.
PROTOHIPPUS
(Hipparion).
MIOCENE.
MIOHIPPUS
(Anchitherium).
MESOHIPPUS.
EOCENE.
OROHIPPUS.

hind-foot.[1] In still older forms the series of the digits will be more and more complete, until we come to the five-toed animals, in which most assuredly the whole series took its origin.

That is what I mean, ladies and gentlemen, by demonstrative evidence of evolution. An inductive hypothesis is said to be demonstrated when the facts are shown to be in entire accordance with it. If that is not scientific proof, there are no inductive conclusions which can be said to be scientific. And the doctrine of evolution at the present time rests upon exactly as secure a foundation as the Copernican theory of the motions of the heavenly bodies. Its basis is precisely of the same character—the coincidence of the observed facts with theoretical requirements. As I mentioned just now, the only way of escape, if it be a way of escape, from the conclusions which I have just indicated, is the supposition that all these different forms have been created separately at separate epochs of time, and I repeat that of such an hypothesis as this there neither is nor can be any scientific evidence, and assuredly, so far as I know, there is none which is supported, or pretends to be supported, by evidence or authority of any other kind. I can but think that the time will come when such suggestions as these, such obvious attempts to escape the force of demonstration, will be put upon the same footing as the supposition made by some writers, who are, I believe, not completely extinct at present, that fossils are not real existences, are no indications of the existence of the animals to which they seem to belong; but that they are either sports of Nature or special creations, intended—as I heard suggested the other day—to test our faith. In fact, the whole evidence is in favor of evolution, and there is none against it. And I say this, although perfectly well aware of the seeming difficulties which have been adduced from what appears to the uninformed to be a scientific foundation. I meet constantly with the argument that this doctrine of evolution cannot be correct, because it requires the lapse of a very vast period of time, and that the duration of life upon the earth thus implied is inconsistent with the conclusions arrived at by the astronomer and the physicist. I may venture to say that I am familiar with those conclusions, inasmuch as some years ago, when President of the Geological Society of London, I took the liberty of criticising them, and of showing in what respects, as it appeared to me, they lacked complete and thorough demonstration. But, putting that point aside altogether, suppose that, as the astronomers, or some of them, and some physical philosophers, tell us, it is impossible that life could have endured upon the earth for as long a period as is required by the doctrine of evolution—supposing that to be proved, what I want to know is, what is the foundation for the statement that

[1] Since this lecture was delivered, Prof. Marsh has discovered in the lowest Eocene deposits of the West a new genus of equine mammals (*Eohippus*), which corresponds very nearly to this description.—*American Journal of Science*, November, 1876.

evolution does require so great a time? The biologist knows nothing whatever of the amount of time which may be required for the process of evolution. It is a matter of fact that those forms which I have described to you occur in the order which I have described in the tertiary formation. But I have not the slightest means of guessing whether it took a million of years, or ten millions, or a hundred millions, or a thousand millions of years, to give rise to that series of changes. As a matter of fact, the biologist has no means of arriving at any conclusion as to the amount of time which may be needed for a certain quantity of organic change. He takes his facts as to time from the geologist. The geologist, taking into consideration the rate at which deposits are formed and the rate at which denudation goes on upon the surface of the earth, arrives at certain more or less justifiable conclusions as to the time which is required for the deposit of a certain amount of rocks, and if he tells me that the tertiary formations required 500,000,000 years for their deposit, I suppose he has good ground for what he says, and I take that as the measure of the duration of the evolution of the horse from the *Orohippus* up to its present condition. And, if he is right, undoubtedly evolution is a very slow process, and requires a great deal of time. But suppose, now, that an astronomer or a physicist—for instance, my friend Sir William Thomson—comes to me and tells me that my geological friend is quite wrong, and that he has capital evidence to show that life could not possibly have existed upon the surface of the earth 500,000,000 of years ago, because the earth would have been too hot to allow of life, my reply is: "That is not my affair; settle that with the geologist, and when you have come to an agreement between yourselves I will adopt your conclusion." We take our time from the geologist, and it is monstrous that, having taken our time from the physical philosopher's clock, the physical philosopher should turn round upon us, and say we are going too fast. What we desire to prove is, is it a fact that evolution took place? As to the amount of time it took, we are in the hands of the physicist and the astronomer, whose business it is to deal with those questions.

I think, ladies and gentlemen, that I have now arrived at the conclusion of the task which I set before myself when I undertook to deliver these lectures before you. My purpose has been, not to enable those of you who have not paid attention to these subjects before to leave this room in a condition to decide upon the validity or the invalidity of the hypothesis of evolution, but to put before you the principles by which all such hypotheses must be judged; and, furthermore, to make apparent to you the nature of the evidence and the sort of cogency which is to be expected and may be obtained from it. To this end I have not hesitated to regard you as genuine students and persons desirous of knowing the truth. I have not hesitated to take you through arguments, even long chains of arguments, that I

fear may have sometimes tried your patience, or to have inflicted upon you details which could not possibly be escaped, but which may well have been wearisome. But I shall rejoice—I shall consider I have done you the greatest service which it was in my power in such a way to do—if I have thus convinced you that this great question which we are discussing is not one to be dealt with by rhetorical flourishes or by loose and superficial talk, but that it requires the keenest attention of the trained intellect and the patience of the most accurate observer. When I commenced this series of lectures, I did not think it necessary to preface them with a prologue, such as might be expected from a stranger and a foreigner; for, during my brief stay in your country, I have found it very hard to believe that a stranger could be possessed of so many friends, and almost harder to imagine that a foreigner could express himself in your language in such a way as, to all appearances, to be so readily intelligible; for, so far as I can judge, that most intelligent, and, perhaps, I may add most singularly active and enterprising body, your press reporters, do not seem to have been deterred by my accent from giving the fullest account of everything that I happen to have said. But the vessel in which I take my departure to-morrow morning is even now ready to slip her moorings; I awake from my delusion that I am other than a stranger and a foreigner. I am ready to go back to my place and country, but, before doing so, let me, by way of epilogue, tender to you my most hearty thanks for the kind and cordial reception which you have accorded to me; and let me thank you still more for that which is the greatest compliment which can be afforded to any person in my position—the continuous and undisturbed attention which you have bestowed upon the long argument which I have had the honor to lay before you.

THE STUDY AND TEACHING OF BIOLOGY.[1]

By Professor H. NEWELL MARTIN, D. Sc., M. B., B. A.

WE meet to-morrow to formally begin the biological work of this University—to commence that systematic study of animal and vegetable form and function, relationship and distribution, which we include under the names of Comparative Anatomy, Zoölogy, Physiology and Botany, or in the general terms Biology or Natural History. I have thought that it might be well to-day to take an opportunity of laying before you what seem to be the ends which we should hold in view, and the methods on which we should work, if we are to attain or to deserve a permanent success. I am further induced

[1] An introductory lecture delivered at the Johns Hopkins University, October 28, 1876.

to take this course by the fact that our present year's work is confessedly of a tentative nature: one main object of it being to enable us to decide upon what lines we are to go forward in the future; and I believe it may facilitate decision on some points if we have before us, as a sort of basis for discussion, a definite statement of views on the subject, no matter how imperfect such statement may be in itself, or how much the opinions expressed in it may afterward be found to require modification. What I propose, therefore, is not simply to tell you what are our arrangements for this year, but also to put before you some thoughts as to what I think we ought to do in the time to come. It is, I am sure, unnecessary for me to dilate at any length, before this audience, upon the interest and importance of biological studies. However contributory to our culture and welfare other studies may be, biology has, and ever must have, a very special interest of its own: it alone deals with the living organisms which surround us, and which are the only things that share with us that wonderful collocation and interaction of natural forces which we call *life*. Biology, too, includes within its range the study of man himself, so far as one side of his nature is concerned; and, as regards his mental and moral qualities, the psychologist and sociologist have already begun to recognize that the progress of their sciences is closely bound up with the development of certain branches of biology. As regards its practical value I might set forth at length the indebtedness of scientific medicine and of sanitary science to biology; but I prefer not to recommend the study to you by such considerations. This is a university: and the object of a university, I take it, is directly to promote liberality of thought and culture, and only indirectly to concern itself with the practical advancement of material welfare. It is concerned rather with the acquirement of a knowledge of principles than with their practical applications; although, in connection with it, it may have subsidiary schools where those who have already learned the principles may acquire a practical knowledge of various arts. Nevertheless it is true that, if we devote ourselves to the higher objects, the rest will be added unto us; for it is one of the great glories of all the physical sciences that, while second to none in the training which a study of them gives to all the faculties of the mind—in the promotion of large and liberal ideas, and in the gratification of that longing to "know," which is the noblest characteristic of the human intellect—they at the same time, as a by-thing, but constantly, contribute to the increase of man's comfort, and to the material prosperity and happiness of his race. Those who advance our knowledge of the laws of animal and vegetable life may work without any immediate outlook to the advancement of medicine, hygiene, and agriculture, but such advancement constantly follows and springs from their work, and will ever do so.

To those who are in any degree acquainted with the state

of the scientific world, the present must seem a specially opportune time for founding a biological school. At no previous period has such an interest been taken in biological problems, or have so many earnest workers been in the field—never before has so rich a harvest been in view. This is mainly owing to the promulgation of two great ideas within the last few years. On the morphological side we have the doctrine of evolution applied to living forms, and especially as definitely put forward by the theory of the origin of species by natural selection; while on the physiological side we have the doctrine of the conservation of energy, and its extension to the play of forces in living organisms. It matters not whether these theories be correct representations of the facts or not, or whether increase of knowledge confirms or upsets them—in any case they have been of incalculable importance in stimulating work and in giving a present and direct significance to its results. I can imagine no time for the biologist to live in which would be more interesting than the coming half-century, or none in which he will have a greater incentive to study; he seems to have almost within his grasp the solution of problems of the widest significance.

Those of us directly concerned in the administration of the biological laboratory here, are charged with the fulfillment of two duties: we have to make provision for the advancement of knowledge, and for its diffusion; we are to find accommodation and assistance for both investigators and students; while we must not suffer those engaged in research to be crowded out by beginners, neither must the beginners be overlooked in providing for those to whom they are one day to succeed. The liberal space at our disposal will permit us, at any rate for the present, to accommodate both classes of workers, without risk of the extermination of either. Meanwhile I have, then, to occupy your time with a few words on two subjects: on biological research, and on biological teaching.

One hears a good deal talked nowadays of scientific research, and among it a good deal of what I cannot but think mischievous nonsense about the peculiar powers required by scientific investigators. To listen to many, one would suppose that the faculty of adding anything whatever to natural knowledge was one possessed by extremely few persons. I believe, on the contrary, that any man possessed of average ability and somewhat more than average perseverance, is capable, if he will, of doing good original scientific work. Any hard-working and commonly intelligent man, who likes his profession, will make a good soldier, or lawyer, or doctor, though that combination of powers which makes the great general, or the great jurist, or the great physician, is given to but few.

So it is with the pursuit of Science: assuredly not every one of her followers, very probably not one among us now present, will be-

come a Linnæus, or a Cuvier, or an Agassiz. It may not be given to any of us to make some brilliant discovery, or to first expound some illuminating generalization; but we can, each and all, if we will, do good and valuable work in elucidating the details of various branches of knowledge. All that is needed for such work, besides some leisure, intelligence, and common-sense (and the more of each the better), is undaunted perseverance and absolute truthfulness; a perseverance unabated by failure after failure, and a truthfulness incapable of the least perversion (either by way of omission or commission) in the description of an observation or of an experiment, or of the least reluctance to acknowledge an error once it is found to have been made. Moreover, this love of truth must extend to a constant searching and inquisition of the mind, with the perpetual endeavor to keep inferences from observation or experiment unbiased, so far as may be, by natural predilections or favorite theories. Perfect success in such an endeavor is, perhaps, unattainable, but the scientific worker must ever strive after it; theories are necessary to guide and systematize his work, and to lead to its prosecution in new directions, but they must be servants, and not masters. I may, perhaps, seem to be insisting at too great length on a self-evident point; but the more one knows of scientific work and workers, the more does one realize the importance and the difficulty of attaining a perfectly-balanced mind and of arriving at an unprejudiced deduction from observation.

I believe, then, that the only absolutely necessary faculties for the scientific investigator are love of his work, perseverance, and truthfulness; to make the great leader and master in science, one of those who cast a new ray of light on our conceptions of the universe, other and far rarer powers are, of course, needed—the most essential being originality of thought; and, as that cannot be either self-taught or taught from outside but must be born in the bone, all that the rest of us can do when we meet such men is to give them a free course and ungrudging help. That an army may attain its best success, needs indeed that every man be brave and loyal, but it is by no means requisite that every soldier be a brigadier-general; so in the army of Science there is place for soldiers of all ranks and capabilities—and, at any rate, we know this, that Nature reveals her secrets, which are her rewards, on no system of purchase or favoritism—what a man deserves that he gets, every drummer-boy who enters her service carries the marshal's *bâton* in his pocket. His reward will be proportionate to the amount of time and intelligence he devotes to his work; given, in addition, certain opportunities which every one has not for himself, but which it is one great object of such institutions as this to provide for all.

If what I have just stated be the general requisites of the scientific investigator, we have next to inquire what special needs has the biologist: these may all be grouped under the head of preliminary train-

ing. He must have a fair knowledge of mechanics, experimental physics, and chemistry; he ought to (I would almost again say he *must*) be able, besides English, to read at least French and German with facility—assuredly, if he cannot, he will labor with much toil and sorrow—and the more mathematics he knows, with the present rapid importation of quantitative ideas into biological science, the better for him; and for certain special branches of biological work there are other special needs. No mistake is more disastrous than the idea that a man can be a botanist and nothing more; a zoölogist, and nothing more; a physiologist, and nothing more. It is true that no one can be master of all the physical sciences, but it is none the less true that hardly one of them can be entirely neglected by the biologist. Animals and plants are, after all, material objects, and live in accordance with the laws that govern matter; but the manifestations of these laws are so often obscured and complicated by the conditions in which they occur in living things, that the understanding of them is only to be got at by approaching them through their simpler manifestations in inorganic bodies. But, apart from that, definite knowledge of various sciences is constantly required by the biologist. How can one ignorant of physics have any real appreciation of the statement that the transmission of a nervous impulse is accompanied by a molecular alteration in the structure of a nerve-fibre, one sign of which is a certain very definite and peculiar alteration in its electrical properties; or how can one ignorant of chemistry grasp the fundamental statement that muscular work is in the long-run dependent on the breaking down of complex chemical molecules into simpler and more stable ones? How can the zoölogist or botanist scientifically study the distribution of animals and plants in space, unless he has a knowledge of physical geography; or in time, unless he knows something of geology? I need not prolong the list.

Furthermore, no one can properly study any branch of biology without some knowledge of its other divisions. The fundamental laws of animal and vegetable life are identical, and only fully realized by comparison; so, while the scientific botanist, to fully appreciate the facts of his own science, must be something of a zoölogist, so must the zoölogist know something of plants: no one living being or group of living beings can be properly understood by itself. To take other examples: how is the morphologist to deal with such problems as those presented to him by rudimentary organs, unless he know something of the functions of parts, which is the special domain of physiology; or, how is he to understand the influence of external conditions in the production and preservation of variations in force, without, again, this knowledge of function? And, as regards the physiologist, he has frequently to search the whole animal and vegetable kingdoms not only to discover those forms which give him the best opportunity of studying certain phenomena, but also to get at those

fundamental ideas which lie at the base of his whole science. What general and broad ideas should we have of the contractility of protoplasm if we only knew it in the highly-specialized form of a muscular contraction; or of its irritability, if we only knew it as exhibited in the nervous apparatus of one of the higher animals? It is quite true that, without any breadth of knowledge, a man may collect, label, and store away thousands of plants; he may macerate and articulate the most beautiful skeletons; he may cut, stain, and mount, the most exquisite microscopic preparations: but assuredly he is not likely to do any work entitled to the name scientific; such mechanical work has its value, no doubt, but it is only preliminary to real scientific work—which latter requires wide knowledge and extended views, and is more valuable the broader the foundation on which it has been built up.

It is this mutual dependence of biological studies which appears to me the justification of grouping together, as we do here, the study of such a number of vast subjects in a single laboratory. By that means each investigator will receive knowledge and assistance from the other; under such a system the desirable intercommunication of ideas is rendered most easy; and we are most likely to escape that narrow specialism which every laboratory in the long-run has a tendency to get into. Of course, no one person is capable of giving detailed assistance in investigations in all the branches of biology; but our staff of professors will doubtless grow, and meantime we shall, I trust, by the associate and fellowship system of the university, have at all times among us well-qualified men in every branch of biology; so that no one fitted for the task, and earnest and willing in its prosecution, who may come here to undertake any special research, will fail to find some one able and willing to advise him when he needs advice, and to assist him when he needs assistance.

What we want here, then, is men with the requisite zeal and training for investigation—we care not whether classification, or morphology, or physiology, or any other branch of biology is their specialty; all we claim is that they shall be able to work, shall mean to work, and shall work—we shall give no quarter to the indolent or ignorant: the former we will not have on any terms, and the latter must enter for the preparatory courses, and will not be allowed to occupy tables set apart for research. Surely, if we select wisely, and find men to work faithfully, we may look forward with confidence to the time when we shall find ourselves in the condition of such laboratories as those of some of the German universities, where, on account of the high class of work done in them, the ablest young men from all over the world beg for admission; where one finds, working side by side, men from every civilized nation, and where, in the presence of the great demand for admission, entry is esteemed a precious privilege.

As to the special aid which we can offer to those who come among us to engage in investigation, it will, of course, depend on two factors,

upon the natural gifts of those charged with the supervision of the laboratory, and the amount of money which those whose duty it is to decide on such matters see right to place at their disposal: for, however important we biologists may think ourselves, the fact remains that there are other studies to be provided for, and studies just as important as our own. For the present I can say, however, that we have at our disposal one large and well-lighted room for general work—a room fitted up for physiologico-chemical investigations—and several smaller rooms for physiological and histological research. As regards instruments we have ordered, and in part received, a very excellent stock, including the most essential ones for every branch of physiological research—and I have no doubt that every year we shall receive grants to add to our stock, and keep up with the times.

The zoölogical and comparative anatomy departments differ from the physiological in not needing so many special instruments; what they mainly need are (besides work-rooms) material for examination and dissection, and books, especially monographs, and those we shall make it a point, to the best of our power, to obtain from time to time as they are wanted. It seems to me that it is not our duty to provide vast herbaria and museums containing every plant and animal under the sun—to provide such collections is the duty rather of the nation than of a university—nor do I think we should be wise to collect and store away things promiscuously, in the hope that some one will want them some time. We should rather concentrate our force on getting what is wanted for the time being. If some one wants to elucidate any point in the structure of the Echinoderms, for example, we should do our best to obtain specimens for him—even from all parts of the world; if some one else wants to work at the embryology of any fish or amphibian, we should again endeavor to get him the eggs in various stages of development, and so on; but I doubt the wisdom of sending out collectors with orders to store away everything they can catch, fish, flesh, and fowl, in spirit, and send it to us. We have nowhere to display such collections if we got them—the vastly greater part of them would never be used—and when reference to extensive collections is necessary, we have always at hand the admirable museum illustrating the fauna and flora of this State which is being brought together by the Academy of Sciences in this city, and the national collections at Washington are within an hour's journey of us. Bringing together from time to time such materials for special researches as I have indicated above, will naturally entail considerable expenditure, but I am sure that the trustees, if they see we mean work, will do all they can to supply our needs.

Now let us turn to the other part of our subject, biological teaching: from part of what I have already said you have doubtless gathered something of my views on this matter. If biology be the complicated study that I have endeavored to indicate, it is in the first

place clear that, in justice both to the student and his teachers, a certain preliminary training must be insisted upon as a preparation for his admission to a biological laboratory; at least the student must have a fair knowledge of physics and chemistry before he comes there; and, when he gets there, the thing next to insist upon is, that his teaching be as largely demonstrative and practical as possible, lectures being made of secondary and laboratory-work of primary importance.

It matters not to me where the student gets this preparatory knowledge; whether here or at some other institution. I believe he ought to acquire it largely at school, as a part of general education; but, as that seems in the present condition of primary education almost impossible, I shall perhaps best make clear my ideas on the matter if I endeavor to sketch out what I think should be the course gone through by a youth fresh from some high-school or college, where he has got an otherwise sound general education, but without anything more than a sham knowledge of physics, and who enters this university with the intention of qualifying himself for biological research or teaching hereafter; and you will, I hope, forgive me if, with the same object of obtaining clearness, I put what I have to say into a somewhat dogmatic form.

Such a person ought to enter at once upon courses of instruction in experimental physics and chemistry, and devote almost wholly his first year to them; but during the latter part of that year, say between the spring vacation and the end of the session, he would, in addition, go through a course of instruction in what we may call general biology. By that I mean a course of instruction in which he would acquire some knowledge of how to use his microscope and how to dissect, and thus gain a certain amount of that special manipulative dexterity which he will require afterward. He would also gain a general acquaintance with biological ideas, and with the meaning of the more important technical terms: he would gain, for example, a real, because a practical, knowledge of what we mean by classification, and of the principles on which classifications are founded; he would learn similarly, with his eyes as well as his ears, what we mean by morphology, and homology, and a host of similar terms; and he would, in addition, acquire a special acquaintance with the structure and actions of certain selected typical animal and vegetable forms. This, then, would finish the first year's work, unless our student should be ignorant of French and German. If so, he ought also to acquire, what is really very easily got, at least a fair reading knowledge of those languages.

At the commencement of his second year the student should enter for two elementary practical courses, one on comparative anatomy and zoölogy, the other on animal physiology. These courses would, I imagine, last about six months each, and they should be taken *pari*

passu. Each would consist, say, of two lectures a week, and the rest of the time would be filled up with the dissection of typical animals, the performance of the simpler physiological experiments, and the preparation and examination of microscopic specimens of animal tissues, all illustrative of the main points put forward in the lectures. The student would also be made to draw sketches of his dissections and microscopic preparations, and to describe them and the results of his experiments briefly in writing, and so while learning thoroughly how to dissect and use his microscope, and the conditions of success in physiological experiment, he would also have his powers of observation regularly trained and tested.

In connection with these courses there should be a museum, containing not a bewildering multitude of specimens, but a small number of dissections and skeletons of typical animals, especially of those which it is important for the student to know, but which are too rare to be obtained in quantities allowing each to dissect one for himself; and these specimens should be so placed that they may be freely accessible to those desiring to study them. It is far better to have to replace an injured specimen occasionally than to have the things locked up behind glass doors, so as to render their thorough examination impracticable to those for whose examination they are placed there. Moreover, especially in connection with the physiological course, there would be needed from time to time, according to the subject-matter of the lectures, demonstrations of certain points; in cases, for instance, needing the employment of the more delicate instruments, or where niceties of manipulation were required, such as a beginner could not be fairly expected to overcome.

I ought perhaps here to refer to the subject of vivisection. Physiology is concerned with the phenomena going on in living things, and vital processes cannot be observed in dead bodies; and from what I have said you will have gathered that I intend to employ vivisections in teaching. I want, however, to say, once for all, that here, for teaching purposes, no painful experiment will be performed. Fortunately, the vast majority of physiological experiments can nowadays be performed without the infliction of pain, either by the administration of some of the many anæsthetics known, or by previous removal of parts of the central nervous system; and such experiments alone will be used here for teaching. With regard to physiological research the case is different: happily here too the number of necessarily painful experiments is very small indeed; but in any case where the furtherance of physiological knowledge is at stake—where the progress of that science is concerned, on which all medicine is based, so far as it is not a mere empiricism—I cannot doubt that we have a right to inflict suffering upon the lower animals, always provided that it be reduced to the minimum possible, and that none but competent persons be allowed to undertake such experiments. Placed,

moreover, as we shall be here, in more or less close connection with a splendidly-equipped hospital, so that we shall be able constantly to combine skilled pathological observation with physiological experiment in an excellent laboratory, we have duties to perform toward the advancement of scientific medicine, from whose performance I believe it would be criminal in us, as it would be shameful, to flinch in any way.

But to return to our special subject: the last three months of the student's second year should be occupied with a laboratory course of instruction in vegetable morphology and physiology, and with a course of lectures on embryology, accompanied with a full practical study of the development of the chick from the earliest stages of incubation.

The student will have now got an extensive acquaintance with biological facts and methods, and henceforth he should be allowed and encouraged to specialize his work. He would be permitted to select for more detailed study in his third year either animal morphology, or botany, or physiology, and the best men in each subject would be picked out and allowed to act as demonstrators to the second-year students, and so be given the opportunity of acquiring a far more accurate knowledge than they could attain in any other way. For these third-year men, too, short advanced courses of lectures would be given from time to time, such as on the physiology of nutrition, the physiology of the senses, the geographical distribution of animals, on special morphological points, and so on, and also on the more important recent discoveries in various branches; and the best of them might be put on some easy bit of original work, to try their metal and whet their appetites.

After all this has been gone through, I think we can do no more in the way of teaching for our typical student; he has now advanced enough to teach himself, and, if he is good for anything, will do it better than others can do it for him. I think that among students so taught, as I have endeavored to indicate, we should be certain to meet with a large number of well-qualified men from among whom to select some of our fellows and associates, and would be justified in expecting from them work of the highest quality. As regards the remainder, those who display no special aptitude for scientific investigation, or no desire to devote themselves to science as a profession, they will at least have had the opportunity of acquiring a very thorough and practical knowledge of what modern biology means.

It now remains for me to give a sketch of what our work for the present year will be, so far as I see my way at present. To-morrow I commence a course of lectures on animal physiology, which I propose to deliver twice a week, on Tuesdays and Fridays, at 1.15 P. M. I have been induced to select this hour on account of special circumstances affecting many of those who wish to attend this year, though as

a general rule I should like an earlier hour, nine or ten in the morning, which definitely brings a man early in the day to the laboratory, and gives me a better chance of getting a good day's work out of him. These lectures will be designed rather for those who have already some knowledge of physiology than for beginners; for so many instruments have not yet arrived, and so many arrangements are necessarily as yet imperfect, that it seems better for the present only to invite men who are more or less fitted by previous training to overcome such occasional difficulties and inconveniences as may from time to time arise from such causes. When I say that the lectures will be rather adapted for advanced students than beginners, I do not mean, however, that I shall omit elementary but important facts, but that, in addition to those, I shall from time to time discuss at more or less length points which are still *sub judice*. The lectures will be illustrated by no experiments: partly because, on account of the rapid changes which go on in living tissues, physiological-lecture experiments are likely to be the reverse of successful (a frog's muscle which has been lying on the table since the commencement of a lecture is very apt to contract abnormally when the lecturer wants it); but mainly because I want each student to make the illustrative observations and experiments for himself—except in cases of unusual difficulty, when demonstrations will be given at such hours as may be found most convenient to the majority. In the lectures I shall presuppose the possession by each present of such a knowledge of anatomy as is necessary for physiological work, and, starting with the structure of blood, go regularly on through the histology and physiology of the tissues and organs of the animal body. These lectures will continue until the spring vacation, and then I mean to set to work specially for more elementary students, and put them through such a course of general biology as I have already described; but possibly either Dr. Brooks or myself will give at that time some instruction in embryology of a more advanced character.

As regards physiological research, several gentlemen have already consulted me with reference to undertaking investigations in different directions, and of course there is plenty of work to be done should others qualified for it present themselves. One difficulty which I have met with is that many seem to consider that a physiological investigation can be carried on by devoting to it an hour or two at irregular intervals: I feel quite sure that no good work is likely to be done in that way, and am not inclined to encourage such workers. Some, at least, of those engaged in investigation will be able to have accommodation in the special rooms, apart from the general laboratory, which have been provided for that purpose.

On the zoölogical and morphological side no arrangements have as yet been made for a lecture and laboratory course this year, nor so far as I know has any such demand as would render it advisable

shown itself. Should it do so, however, we may, perhaps, make arrangements for elementary instruction in those subjects, under the more immediate superintendence of Dr. Brooks, our associate in biology, upon whose shoulders I must throw most of the burden of that side of the work. We shall, at any rate, collect material and make other preparations for such a course next year. After Christmas Dr. Brooks will give a course of lectures on "Morphological Theories."

For the present, too, we shall have in the laboratory several well-trained zoölogists and morphologists; some engaged in prosecuting advanced studies, others in research. I fancy all of them are (as they ought to be) pretty well qualified to take care of themselves; but Dr. Brooks and myself will do our best to give them such assistance as they may need, and to make arrangements by which they can be supplied with such material as they require.

In conclusion, let me say a word to those of you here present who are to be the first workers with me in this laboratory. It behooves you as well as me to recognize what a heavy responsibility lies upon us. Upon the work that we do and the spirit in which we do it, upon the character we give our laboratory at its start, much of its future success or failure depends. If we all work honestly and thoroughly, it will win esteem and reputation; if we are careless and half-hearted, it will become of low repute. Let us, then, each work loyally, earnestly, truthfully, so that when the time comes, as it will come sooner or later, in one way or another, to each of us, to depart hence, we may carry with us a good conscience, and be able to say that in our time no slipshod piece of work ever left the laboratory; that no error we knew of was persisted in; that our only desire was to know the truth. Let us leave a record which, if it perchance contain the history of no great feat in the memory of which our successors will glory, will at least contain not one jot or one tittle of which they can be ashamed.

THE PARALLEL ROADS OF GLEN ROY.

FROM a lecture recently delivered by Prof. Tyndall before the Royal Institution, we gather the following facts in regard to that natural wonder in Scotland, which for so long remained a puzzle to all investigators. There is an unusual interest centred around its history, from the time when the country-people explained it by their crude and half-mythical theories, to the time when it became a labor of love for the untiring efforts and acute observations of scientists.

The earliest published allusion to these roads was made in a work brought before the public a century ago, but no systematic description of them appeared before 1817. They are found in the district of

Lochaber, Inverness-shire. On both sides of the steep, narrow glen through which the Roy runs, there are three perfectly horizontal and parallel roads, directly opposite on each side, those on one side corresponding exactly in elevation to those on the other. They are respectively 1,150, 1,070, and 860 feet above the sea, and are formed as shelves in the yielding drift which covers the sides of the mountains. They usually slope somewhat from the hill, and vary in width from one to twenty yards. The two highest stop abruptly at different points near the mouth of Glen Roy, although no barrier now remains to show any reason for it. At some points the grass on the shelves differs from that which is above and below, and, as the roads lie in the midst of heather-covered hills, the absence of the dark shrub from them adds greatly to their conspicuousness.

The terraces were originally supposed to have been made for the heroes whose deeds have been sung by Ossian. A less romantic view was that "they were designed for the chase, and were made after the spots were cleared in lines from wood, in order to tempt the animals into the open paths after they were roused, in order that they might come within the reach of the bowmen who might conceal themselves in the woods above and below." In 1816 Playfair believed them to be aqueducts for artificial irrigation. In 1817 Dr. MacCulloch discussed the probability of there having been lakes embosomed in Glen Roy at one time, and supposed that these roads were the margins of the lakes. It remained, however, for Sir Thomas Dick-Lander to bring forward the facts of the subject, and place them in a scientific light. Adjacent to Glen Roy is Glen Gluoy, along the sides of which there is a single terrace or road, having the same elevation on each side of the valley, and similar in all respects to the roads of Glen Roy. Wishing to see whether these two sides would be united at the head of the glen, and in what manner, he followed them into the mountains. As the valley gradually rose, he observed the shelves approaching each other more nearly; and finally, at the head of Glen Gluoy, he discovered a water-shed of exactly the same elevation as the road which swept around the glen. This height was found to be 1,170 feet, or 20 feet higher than the upper road of Glen Roy. From this water-shed he passed through a lateral branch-valley to Glen Roy, descended to the highest road, and followed it up the glen as he had pursued the previous road. In the same manner he came upon a water-shed looking into Glen Spey, and of precisely the same elevation as the road. After this he dropped down to the lowest shelf, and followed it to the mouth of the glen. It did not end here, however, but doubled around the hills, and ran along the sides of the mountains which flank Glen Spean. Continuing eastward, he observed the Spean Valley gradually approaching the road until the two were on a level, when, as in the other cases, he discovered a water-shed.

From these facts, convinced that water alone could have produced

the terraces, he saw that if the mouth of Glen Gluoy were stopped by a barrier, the waters from the surrounding mountains would be collected in the valley until they had reached the water-shed, when any further rise would be prevented by the branch-valley, which would carry the additional water off to Glen Roy. As long, then, as the barrier remained, there would be a lake in Glen Gluoy, at the exact level of the road, which, by constant action upon the loose drift,

PARALLEL ROADS OF GLEN ROY.

would be sufficient to produce the road. Now, if the mouth of Glen Roy should also be barred at the same time by a sufficiently high barrier, the waters would be collected behind it, the surface of the lake would rise till it reached the water-shed dividing Glen Roy from Glen Spey, when the superabundant water would flow into the latter valley. In this way the highest shelf of Glen Roy would be formed. If its barrier were now to be partly removed, so as to establish a connection between it and the upper part of Glen Spean, while the lower part remained blocked up, upper Glen Spean and Glen Roy would then be occupied by a continuous lake, the level of which would be determined by the water-shed discovered in Glen Spean. The water in Glen Roy would take a level corresponding to its new place of escape, and the lowest parallel road would be formed. The conclusions thus drawn would be strictly logical, if proof could be offered as to the existence of the barriers.

In Glen Spean there is a large quantity of detritus, and Sir Thomas Dick-Lander supposed that this had at one time been heaped up by some unknown convulsion. As he could not account for the middle

road of Glen Roy in the same manner, he assumed that at a certain point—the level of this road—the barrier which had been wasting away held its ground for a sufficiently long time to form the road. But, on the same principle, there would naturally have been a greater number of roads in this glen, and additional roads in the other glens. A weakness was thus admitted into the theory which was immediately attacked by Mr. Darwin. He believed that the whole region had once been covered by the sea, and that, in the upheaval of the earth, there were pauses during which these roads were formed. But this would not account for the sea being higher in one of the glens than in another, nor for the unequal number of terraces by which the mountains are belted. As soon as Mr. Darwin detected these fallible points, he abandoned his theory.

In 1847 the Dick-Lander hypothesis received new strength from a discovery made by Mr. Milne-Home. There is a lateral glen, called Glen Glaster, running eastward from Glen Roy, which had escaped the notice of Sir Thomas Dick-Lander. Mr. Milne-Home entered this glen, pursued a branch of it extending to the southeast, and came upon a water-shed exactly level with the second Glen Roy road. On the same theory as before, when the barrier should be properly removed, the water in Glen Roy would sink to the second road, and the surplus water would escape over the Glen Glaster water-shed into Glen Spean. But this mode of explanation could not yet be accepted, for there is scarcely a trace left of the immense quantity of detritus that would have been necessary to form the barriers. Nor could the detritus have been swept away by glaciers, for there have been no glaciers in these valleys since the retreat of the lakes.

At the time when Sir Thomas Dick-Lander was making his investigations, the action of ancient glaciers was not understood. The subject had been pursued in Switzerland, but it was not till 1840 that unmistakable marks of glacier-action were pointed out in Great Britain by Agassiz. He visited Glen Roy, and, having detected the traces of glaciers, pronounced these to have been the barriers blocking up the glens. This theory was afterward examined and confirmed by Mr. Jamieson. "It was their ascription to glacier-action," says Prof. Tyndall, "that first gave the parallel roads of Glen Roy an interest in my eyes; and in 1867, with a view to self-instruction, I made a solitary pilgrimage to the place, and explored pretty thoroughly the roads of the principal glen." At different places he found that the effects of the lapping of the water on the more friable portions of the rock are still perfectly distinct. Several months ago he again visited the place, prior to delivering a lecture upon the subject. The entire ground was thoroughly explored, and the principal hills were found to be intensely glaciated. The collecting-ground of these glaciers, which blocked up the valleys, were the mountains south and west of Glen Spean—among others, Ben Nevis. These lofty mountains en-

counter the southwestern Atlantic winds, and deprive them of their vapor. During the glacial epoch this vapor was precipitated as snow, which slid down the slopes, while every valley and recess kept up a constant supply of glaciers into Glen Spean, filling it to an ever-increasing height. There would of course be ice in Glen Spean, and water to the north of it, as the winds in passing north would be partly dried and warmed by the liberation of their latent heat. As long as the supply was in excess of the consumption, the dams closing the glens would increase in height. As the weather grew warmer, the opposite would be true. For a long time the conflict would continue, retarding indefinitely the disappearance of the barriers, but the ice in the end would have to give way. "The dam at the mouth of Glen Roy, which probably entered the glen sufficiently far to block up Glen Glaster, would gradually retreat. Glen Glaster and its water-shed being opened, the subsidence of the lake 80 feet, from the level of the highest to that of the second parallel road, would follow as a consequence." "In presence, then, of the fact that the barriers which stopped these glens to a height, it may be, of 1,500 feet above the bottom of Glen Spean, have dissolved, and left not a wreck behind; in presence of the fact insisted on by Prof. Geikie, that barriers of detritus would undoubtedly have been able to maintain themselves had they ever been there; in presence of the fact that great glaciers once most certainly filled these valleys—that the whole region, as proved by Mr. Jamieson, is filled with the traces of their action—the theory which ascribes the parallel roads to lakes dammed by barriers of ice has, in my opinion, an amount of probability on its side which amounts to a practical demonstration of its truth."

SCIENCE IN AMERICA.[1]

By Professor JOHN W. DRAPER, M. D., LL. D.

GENTLEMEN, Members and Associates of the American Chemical Society: In accordance with the plan of the American Chemical Society, I am called upon to address you this evening. I have to congratulate you on its successful establishment, and its prospect of permanent success.

Let us consider some of the reasons which would lead us to expect that success, not only for our own, but also for other kindred societies. The field of Nature is ever widening before us, the harvest is becoming more abundant and tempting, the reapers are more numerous. Each year the produce that is garnered exceeds that of the preceding.

[1] Inaugural address before the American Chemical Society, delivered at Chickering Hall, New York, November 16, 1876.

In all directions there is good hope for the future. Perhaps, then, you will listen without impatience for a few minutes this evening to one of the laborers who has taken part in the toil of the generation now finishing its work, who looks back, not without a sentiment of pride, on what that generation has done, who points out to you the duties and rewards that are awaiting you, and welcomes you to your task. Let us look at the prospect before us.

The progress of science among us very largely depends on two elements: fiirst, on our educational establishments; second, on our scientific societies. To each of these I propose to direct your attention; and, first, of our colleges:

Prof. Silliman, in his address delivered on the occasion of the centennial of chemistry, at the grave of Priestley, in commemoration of the discovery of oxygen, makes this remark: "The year 1845 marks the beginning of a new era in the scientific life of America, which is still in active progress, and chemistry has had its full share in this advance." He then enumerates the causes which, in his opinion, had brought about this increased activity. Among them are the centennial celebration of the American Philosophical Society, in Philadelphia, in 1843; the reorganization of the United States Coast Survey, in 1845; the establishment of the Smithsonian Institution at Washington, in 1846; the enlargement of the *American Journal of Science*, in the same year; the contemporaneous foundation of the Astronomical Observatory at Cincinnati; the institution of the Analytical Laboratory at Yale College, in 1847; and, simultaneously, the Lawrence Scientific School at Harvard. To these he adds especially the establishment of the American Association for the Advancement of Science, in 1848. Coinciding with him fully as to the character and power of these and other local causes which he mentions, I cannot but regard them as being themselves the issues of influences of a much more general kind.

A revolution had been taking place in Europe—a revolution not so much political as industrial or social, though it was followed by political consequences of the most important nature. Its commencements may be seen in the preceding century, in the canal-engineering of Brindley; in the improvements of iron-manufacture; in the construction of all kinds of machinery, which reached its acme when the hand of man was deposed from its office, and, through the slide-rest and planing-machine, engines were made by themselves. Then came the exquisite contrivances for the manufacture of textile fabrics, so that a man could do as much work in a day as he had formerly done in a year, the movement in that direction culminating in the two steam-engines, the condenser and non-condenser. The demand for cotton rose; the value of the slave, its cultivator, was enhanced; and the negro question became the paramount political question in the United States. See how scientific discoveries and inventions lead to

political results! Herein, among other great events, we find the origin of the American civil war!

In Europe, the social effect of the use of steam was strikingly marked. Performing mechanical drudgery, it relieved vast numbers of the laboring-class, and gave them time to think. It concentrated them in factories and mills. Those industrial hives were pervaded by literary influences, perhaps not always of a kind that we should approve of. They became the seats of agitation in politics and theology, and, while this was the effect on the laboring mass, the owners or capitalists were accumulating enormous fortunes.

We may excuse the enthusiastic literature of the cotton-manufacture its boasting, for men had accomplished works that were nearly godlike. Mr. Baines, writing in 1833, states that "the length of cotton-yarn spun in one year was nearly five thousand millions of miles —sufficient to pass round the earth's circumference more than two hundred thousand times, sufficient to reach fifty-one times from the earth to the sun. It would encircle the earth's orbit eight and a half times. The wrought fabrics of cotton exported in one year would form a girdle for the globe, passing eleven times round the equator, and more than sufficient to form a continuous sheet from the earth to the moon." And let us not forget that, to give commercial value to this vast result, the capital chemical discovery of bleaching by chlorine was essential. Such was the condition of things in England just previously to the epoch in question. Necessarily, it was followed by great social results.

But there was something more. The locomotive absolutely revolutionized society. A man could now travel farther in an hour than he had previously done in a day. Again, it was clear that important political results were occurring. The effect of the railroad was to render nations more homogeneous, to destroy provincialism. It is actually true that language underwent a change. No one who has remarked the various dialects of the English counties prior to the opening of the Liverpool & Manchester Railway, and the homogeneousness of speech which is fast displacing them, can be blind to this. Simultaneously, a redistribution of the population took place. It was largely withdrawn from the open country, and concentrated in the towns.

In this statement I am recalling facts so common that they are familiar to us all. We all appreciate the immense social changes that took place just before 1845. Who in those times could fail to perceive that grand consequences must follow the expenditure of thousands of millions of dollars in the building of railroads, who, when he saw the labor of a year shrinking into the compass of a day, the travel of a day into the compass of an hour, the thought of man outstripping the velocity of light—who could be so obtuse as not to discern that a new agency had taken possession of the earth, that it

was agitating the nations to their very foundations, that it was ameliorating the lot of man, increasing his power, and dealing remorselessly with old ideas, the fictions and fallacies of the past!

Can we wonder, then, that those who were growing up in the midst of these marvels should not only contrast the activity by which they were surrounded with the stagnation of preceding centuries, but should demand to be made acquainted with the power that was thus opening a new world before their eyes? Very soon it became apparent that there was no provision in the existing educational establishments, the universities and colleges, for this unexpected state of things. These were, to be sure, good enough to initiate a bench of boys into the method of translating an ode of Horace or a few lines of Sophocles, but something more substantial than that was wanted now.

This was the true cause of that influence which began to be felt in America about 1840. Every reflecting person saw that a change in public education was imperative; nay, more was impending. Confronted by the vigor of modern ideas, the system that had come down from the dark ages was seen to have become obsolete.

In addition to these influences, there was another at which we must for a moment glance. Let me, in a few words, sketch its history.

The peninsula of Italy was separated from the rule of the Greek emperors in the eighth century, mainly in consequence of the iconoclastic dispute. Partly through the stress of circumstances, and partly as a matter of policy, the Latin language was brought into such prominence that it was supposed to contain all the useful knowledge in the world. In Western Europe, at the close of the fourteenth century, Greek was totally forgotten.

But when it became clear that Constantinople would be taken by the Turks, many learned men fled to the West, bringing with their language precious classical manuscripts. As it was feared, however, by the dominant authority that knowledge and opinions of an unsuitable kind might thus be introduced, Greek obtained a foothold with much difficulty, and it was only by the aid of Florence, Venice, and other commercial towns of Upper Italy, that after a struggle it made good its ground. The Latin had now a successful rival.

A century later brings us to the culmination of the Reformation. Its literary issue was an admiration of the language of that much-enduring, that immortal race to whom the Old Testament is so largely due. As had been the case with Greek, so now Hebrew passed from a condition of neglect to one of extravagant exaltation. It was believed to have been the original language of the human race, a conviction that proved to be a great stumbling-block to the progress of learning. There were thus three classical languages, each having its own paramount claim.

In 1784 the Royal Asiatic Society was instituted in Bengal. One

of its earliest and most important services was that it brought the Sanskrit language emphatically to the knowledge of Europe. The similarity of this to Latin and Greek, especially in the grammatical forms, struck every one with surprise. At first the old literary party resisted its claims, some of them even affirming that it never had been a spoken tongue, but that it had been fictitiously constructed out of Latin and Greek. The creation of comparative grammar by the great German scholar Bopp, in 1816, threw a flood of light on the subject; and the discovery in 1828, by Hodgson, of the Buddhistic sacred writings in Nepaul, revealed to astonished Europe a literature of grand antiquity and prodigious extent, in which is contained the religious belief of 400,000,000 men—ten times the present population of the United States. Greek and Latin had now to descend from the imperial thrones on which they had been seated, and take their places as later and less perfect forms of this wonderful Oriental tongue.

In the higher regions of literature all over Europe, these discoveries made a profound impression. It was at once seen by the great scholars of the times that the existing educational system, founded, as it so largely was, on the languages of the Mediterranean peninsulas, was altogether on an imperfect basis. They saw that philology was about to occupy a higher platform, and that, though it might cost a struggle with present interests, a change in public education was necessary. But though these languages have suffered an eclipse, there still remains that priceless heritage which they have transmitted to us—immortal examples in national life, in patriotism, in statesmanship, in jurisprudence, in philosophy, in poetry. Still there remain the ruins of the Parthenon, the relics of those statues which have no rival elsewhere in the world—embodiments of the beautiful, before which, even at the risk of being denounced as a pagan, a man might fall down and worship. Still there remains the history of that awful empire which once bore sway around the Mediterranean Sea, an empire to which we owe our civilization, our religious convictions, and even our modes of thought.

I add this great discovery in letters to the scientific and industrial movement I have described as bringing on the epoch of 1840.

Educational institutions are in their nature very much under the influence of the past. They are guided by men of the parting generation, and are essentially conservative. The changes they began to manifest did not originate within them, but were forced upon them from without. They clung to the mediæval as long as they could, and only accepted the modern when they were compelled.

Among American colleges which are emancipating themselves from the mediæval, we may number Columbia, Cornell, Harvard, Princeton, University of Virginia, Yale. Doubtless there are many others that would follow the example if they could, but they are fettered with the gyves of sectarian or local restraint. They march

along, daintily and grotesquely, in the pointed shoes of the fourteenth century.

I linger on this subject of colleges because the example of other countries, and especially of Germany, proves to us that on them our hopes for the development of science must very largely rest. The scientific glory of Germany, not inferior in brilliancy to its military glory, is the creation of its university professors. Among them we find the great chemists and physicists, whose works we study with delight.

Our colleges must separate themselves from the mediæval, and assume thoroughly and sincerely the modern cast. Sincerely, I say, for not a few of them indulge in deception. They would have us believe that they teach physics when they have no modern apparatus; chemistry, when they have no laboratory; botany, without any garden, herbarium, or even drawings; geology, mineralogy, natural history, without any cabinets. So ignorant are some boards of trustees and faculties, that they hold such equipments as luxuries easily dispensed with. I have known some go so far as to affirm that as much money ought to be expended in teaching a few boys Latin and Greek as in giving a demonstrative and illustrated course of science, and even to act on that principle. In institutions under this kind of influence, you will always find that their whole weight is thrown toward the æsthetic. Whatever college honors there may be, whatever emoluments, pass in that direction; and, though through fear of public opinion science cannot be ignored, it is simply tolerated, not cultivated.

From our colleges we may in the second place turn to our scientific societies.

I have referred to the period at which the Greek language became cultivated in Western Europe. The first societies were those established in Florence by its admirers. In the Medicean gardens the lovers of Plato assembled to restore, under an Italian sky, the philosophy that had been extinguished in Athens, and to commemorate by a symposium the birthday of that illustrious man. There is a pleasure in associating with those whose thoughts are congenial to our own, in breathing an atmosphere in which the intellectual makes itself felt.

Very soon the example was imitated. Persons who had a love for science followed the example of those who had a love for letters. The *Academia Secretorum Naturæ* was instituted at Naples in 1560, by Baptista Porta, the inventor of the camera which photographers now so much use; the Lyncean Academy for the Promotion of Natural Philosophy, in 1603; the Royal Society of London, 1645; the Royal Academy of Sciences in Paris, 1666; the Berlin Academy of Arts and Sciences, in 1700. Leibnitz, the rival of Newton, was its first president.

When the Royal Society of London was founded it encountered a bitter opposition. Had it not been for the "merry monarch," Charles II., it must have succumbed beneath the fierce maledictions launched against it.

As in Italy, when the opportunity was offered, men of the same inclination of thinking sought each other, so here, to the surprise of the most enthusiastic chemists, when such an association was proposed, persons seeking membership came crowding in. The society I have the honor of addressing this evening was the result. Already it has completely organized itself; already it has published the first number of its "Proceedings," a publication which I am sure will procure for it approval and respect.

In these organizations of scientific effort, an opportunity of assisting is given to those who, not having dedicated themselves to philosophical pursuits, have yet achieved success in other walks of life, and who, recognizing that the progress of civilization very largely depends on the increase of knowledge, may desire to aid in promoting that great result by the application of their means. See what immense benefits have arisen from the money grants that foreign governments have placed at the disposal of their scientific bodies; see what a stimulus there has been in the award of medals of honor, and, if you desire to witness the effect of a well-judged benefaction, look at the Smithsonian Institution. I would not say one word in disparagement of gifts to colleges and universities, for it is indeed a noble purpose; but endowments for the promotion of a knowledge of Nature conferred on scientific societies for the good of all men, no matter what their country or color, no matter what their religious profession or political condition, are still nobler. The one is a local and transitory benefaction, the other an enduring and universal benevolence.

In our own special science, chemistry, all that has been done has only served to extend the boundary of what remains. The thousands of analyses that have been made have brought us into a wilderness of results. We have not been able to rise to a point of view sufficiently high to discover what is the true place of those results in Nature. We try to represent on the pages of our books and on our black-boards formulas of the constitution of things, conscious all the time that these are at the best only convenient fictions, which must necessarily change as we gain a more perfect insight into that grandest of all problems, the distribution of Force in Space, and the variations to which it is liable. The geometry of chemistry is that of three dimensions, not of two. We have to consider the relation of points not situated on one plane, and hence it is necessary to employ three axes of reference; nay, even more, we cannot avoid the conception of the mathematical method of quaternions. Our inadequate information respecting the real grouping of atoms is followed as a necessary con-

sequence by imperfection in our methods of nomenclature, the confusion in this respect becoming, as we all too well know, every day worse and worse.

And now, while we have accomplished only a most imperfect examination of objects that we find on the earth, see how, on a sudden, through the vista that has been opened by the spectroscope, what a prospect lies beyond us in the heavens! I often look at the bright-yellow ray emitted from the chromosphere of the sun, by that unknown element, Helium, as the astronomers have ventured to call it. It seems trembling with excitement to tell its story, and how many unseen companions it has. And if this be the case with the sun, what shall we say of the magnificent hosts of the stars? May not every one of them have special elements of its own? Is not each a chemical laboratory in itself? Look at the cluster in the sword-handle of Perseus; in Cassiopeia, a universe of stars on a ground of star-dust; in Hercules—of which, as astronomers say, no one can look at for the first time through a great telescope without a shout of wonder—the most superb spectacle that the eye of man can witness! Look at the double stars of which so many are now known, emitting their contrasting rays, garnet, or ruby, or emerald, or sapphire. Each is in accordance with its own special physical conditions, though all are under the same universal ordinance.

Now, here a fact of surpassing importance presses itself on our attention. The movements taking place in those distant bodies are taking place under the same laws that prevail here on earth, and in our solar system. The law of gravitation, as developed by Newton, bears sway in all those distant worlds. In them bodies attract each other with forces directly as their masses and inversely as the squares of their distances. There the laws of the emission, absorption, and transmission of light are the same as they are with us. There ignited hydrogen gives forth its three rays, the same rays that it gives forth to us. In the uttermost parts of the universe the law of definite combination, the numerical law, and the multiple law, stand good. Sodium absorbs its two waves of definite refrangibility, and iron gives in the spectra its more than a hundred lines, more than a hundred silent but convincing witnesses of the uniformity of the constitution of the universe. There the number of vibrations that constitute a ray of definite refrangibility is the same we have found it to be here. In the enormous heat of those central suns the dissociation of molecules may be of a higher order than we can reach artificially, but the law under which it takes place is a continuation of the law here. There, though the weight of a given mass of matter is different from what it is with us, it is nevertheless determined by the law that determines here—the law of gravitation. There energy is indestructible, and is measured as it is measured among us, by work. Then is there any boundary that we can assign to natural law—is it not omnipresent, universal?

Perhaps there is no exaggeration in the assertion—for there seems abundant proof of its truth—that the light by which we see some of those distant orbs has crossed through such a prodigious space that millions of years have transpired during the journey. Then the phenomena it brings to us are those that were engendered in the beginning of the vast time so passed. Whatever there is that is in harmony with facts now happening here, is to us an unimpeachable evidence that the laws which were governing in those old ages have undergone no depreciation, but are active as ever until now. Then shall I exaggerate if I say that those laws are eternal in duration?

Infinite in influence, eternal in duration, what a magnificent spectacle! In the resistless energy of the motions of the universe is there not omnipotence? The Omnipotent, the Infinite, the Eternal, to what do these attributes belong?

Shall a man who stands forth to vindicate the majesty of such laws be blamable in your sight? Rather shall you not with him be overwhelmed with a conception so stupendous? And yet let us not forget that these eternal laws of Nature are only the passing thoughts of God.

But, grand as this is, there is something still grander. There is another temple into which we have to pass, not that of the visible but that of the invisible. We must persist in the invasion we have made, in the revolution we have brought about in physiology. We have to determine the laws which preside in the nervous system of man, and discover the nature of the principle that animates it. Is there not something profoundly impressive in this, that the human mind can look from without upon itself, as one looks at his phantom image in a mirror, and discern its own lineaments and admire its own movements? My own thoughts have of late years been forcibly drawn to this, from a recognition that the interpretation by the mind of impressions from without takes place under mathematical laws, as, for instance, that when external ethereal vibrations create in the mind a certain idea, that same idea will arise when the vibrations are doubled, or tripled, or quadrupled in frequency; but other ideas will be engendered by vibrations of an intermediate rate. Yet what these ideas will be may be predicted. It is true that this is only an optical case, but it extends the view that has been offered to us by a study of the structure of the ear. In the labyrinthine compartment of that organ the ultimate fibres of the auditory nerve are laid on the winding plane of the spiral lamina, in ever-decreasing lengths, each capable of trembling to the sound which is in unison with it—a mechanical action truly, answering to the sympathetic vibration with which the strings of a piano will respond to the corresponding notes of a flute—and these are translated by the mind into all the utterances of articulate speech, all the harmonies of music—speech that engenders new ideas within us, strains which, though they may die away in the air, live

forever in the memory. The exquisite delight we experience in listening to the works of our great composers arises thus in mechanical movements, which are the issue of mathematical combinations. The unseen world is under the influence of number!

But what is number except there be one who numbers? When Pompey, in his Syrian war, broke into the holy of holies at Jerusalem, he expressed, as Tacitus tells us, his astonishment that there was no image of a divinity within; the shrine was silent and empty. And so, though after death we may anatomize and explore the inmost recesses of the brain, the veiled Genius that once presided there has eluded us, and has not left so much as a phantom-trace, a shadow of himself.

The experiments of Galvani and Volta have not yet reached their conclusion; those of Faraday and Du Bois-Reymond have only yielded a preliminary suggestion as to the nervous force. Excepting the great sympathetic nerve, the nervous fibres themselves are, as is well known, of two classes—those that gather the impressions of external things and convey them to the nerve-centres, and those that transmit the dictates of the will from within outwardly. The capabilities of one of the former—the apparatus for sight—have been greatly improved by various optical contrivances, such as microscopes and telescopes, an earnest of what may hereafter be done as respects the four other special organs of sense; and, as concerns the second class, the result of mental operations, the resolves of the will, may be transmitted with greater velocity than even in the living system itself, and that across vast terrestrial distances, or even beneath the sea. Telegraphic wires are, strictly speaking, continuations of the centrifugal nerves, and we are not without reason for believing that it is the same influence which is active in both cases.

In a scientific point of view, such improvements in the capabilities of the organs for receiving external impressions, such extensions to the distances to which the results of intellectual acts and the dictates of the will may be conveyed, constitute a true development, an evolution, none the less real though it may be of an artificial kind. If we reflect carefully on these things, bearing in mind what is now known of the course of development in the animal series, we shall not fail to remark what a singular interest gathers round these artificial developments—artificial they can scarcely be called, since they themselves have arisen interiorly. They are the result of intellectual acts. Man has been developing himself. He, so far as the earth is concerned, is becoming omnipresent. The electrical nerves of society are spread in a plexus all over Europe and America; their commissural strands run under the Atlantic and the Pacific.

In many of the addresses that have been made during the past summer, on the Centennial occasion, the shortcomings of the United

States in extending the boundaries of scientific knowledge, especially in the physical and chemical departments, have been set forth. "We must acknowledge with shame our inferiority to other people," says one. "We have done nothing," says another. Well, if all this be true, we ought perhaps to look to the condition of our colleges for an explanation. But we must not forget that many of these humiliating accusations are made by persons who are not of authority in the matter; who, because they are ignorant of what has been done, think that nothing has been done. They mistake what is merely a blank in their own information for a blank in reality. In their alacrity to depreciate the merit of their own country, a most unpatriotic alacrity, they would have us confess that for the last century we have been living on the reputation of Franklin and his thunder-rod.

Perhaps, then, we may without vanity recall some facts that may relieve us in a measure from the weight of this heavy accusation. We have sent out expeditions of exploration both to the Arctic and Antarctic seas. We have submitted our own coast to an hydrographic and geodesic survey, not excelled in exactness and extent by any similar works elsewhere. In the accomplishment of this we have been compelled to solve many physical problems of the greatest delicacy and highest importance, and we have done it successfully. The measuring-rods with which the three great base-lines of Maine, Long Island, Georgia, were determined, and their beautiful mechanical appliances, have exacted the publicly-expressed admiration of some of the greatest European philosophers, and the conduct of that survey their unstinted applause. We have instituted geological surveys of many of our States and much of our Territories, and have been rewarded not merely by manifold local benefits, but also by the higher honor of extending very greatly the boundaries of that noble science. At an enormous annual cost we have maintained a meteorological signal system, which I think is not equaled and certainly is not surpassed in the world. Should it be said that selfish interests have been mixed up with some of these undertakings, we may demand whether there was any selfishness in the survey of the Dead Sea? Was there any selfishness in that mission which a citizen of New York sent to equatorial Africa for the finding and relief of Livingstone, any in the astronomical expedition to South America, any in that to the valley of the Amazon? Was there any in the sending out of parties for the observation of the total eclipses of the sun? It was by American astronomers that the true character of his corona was first determined. Was there any in the seven expeditions that were dispatched for observing the transit of Venus? Was it not here that the bi-partition of Bela's comet was first detected, here that the eighth satellite of Saturn was discovered, here that the dusky ring of that planet, which had escaped the penetrating eye of Herschel and all the great European astronomers, was first seen? Was it not by an American telescope that the companion

of Sirius, the brightest star in the heavens, was revealed, and the mathematical prediction of the cause of his perturbations verified? Was it not by a Yale College professor that the showers of shooting-stars were first scientifically discussed, on the occasion of the grand American display of that meteoric phenomenon in 1833? Did we not join in the investigations respecting terrestrial magnetism instituted by European governments at the suggestion of Humboldt, and contribute our quota to the results obtained? Did not the Congress of the United States vote a money-grant to carry into effect the invention of the electric telegraph? Does not the published flora of the United States show that something has been done in botany? Have not very important investigations been made here on the induction of magnetism in iron, the effect of magnetic currents on one another, the translation of quantity into intensity, and the converse? Was it not here that the radiations of incandescence were first investigated, the connection of increasing temperature with increasing refrangibility shown, the distribution of light, heat, and chemical activity in the solar spectrum ascertained, and some of the fundamental facts in spectrum analysis developed long before general attention was given to that subject in Europe? Here the first photograph of the moon was taken, here the first of the diffraction spectrums was produced, here the first portraits of the human face were made—an experiment that has given rise to an important industrial art!

Of our own special science, chemistry, it may truly be affirmed that nowhere are its most advanced ideas, its new conceptions, better understood or more eagerly received. But how useless would it be for me to attempt a description in these few moments of what Prof. Silliman, in the work to which I have already referred, found that he could not include on more than 100 closely-printed pages, though he proposed merely to give the names of American chemists and the titles of their works! It would be equally useless and indeed an invidious task to offer a selection; but this may be said, that among the more prominent memoirs there are many not inferior to the foremost that the chemical literature of Europe can present. How unsatisfactory, then, is this brief statement I have made of what might be justly claimed for American science! Had it been ten times as long, and far more forcibly offered, it would still have fallen short of completeness. I still should have been open to the accusation of not having done justice to the subject.

Have those who gloat over the shortcomings of American science ever examined the Coast Survey reports, those of the Naval Observatory, the Smithsonian contributions, those of the American Association for the Advancement of Science, the proceedings of the American Academy of Arts and Science, those of the American Philosophical Society, the Lyceum of Natural History, and our leading scientific periodicals? Have they ever looked at the numerous reports pub-

lished by the authority of Congress on geographical, geological, engineering, and other subjects—reports often in imposing quartos magnificently illustrated.

Not without interest may we explore the origin of the depreciation of which we thus complain. In other countries it is commonly the case that each claims for itself all that it can, and often more than is its due. Each labors to bring its conspicuous men and its public acts into the most favorable point of view; each goes upon the maxim that a man is usually valued at the value he puts upon himself. But how is it with us? Can any impartial person read without pain the characters we so often attribute to our most illustrious citizens in political and, what is worse, in social life? Can we complain if strangers accept us at our own depreciation, whether of men or things?

We need not go far to detect the origin of all this—it is in our political condition. Here wealth, power, preferment—preferment even to the highest position of the nation—are seemingly within the reach of all, and in the internecine struggle that takes place every man is occupied in pushing some other man into the background.

I fear that in political life there is no remedy for this, such is the violence of the competition, so great are the prizes at stake. But in the less turbulent domain of science and letters we may hope for better things. And those who make it their practice to decry the contributions of their own country to the stock of knowledge may perhaps stand rebuked by the expressions that sometimes fall from her generous rivals. How can they read without blushing at their own conduct such declarations as that recently uttered by the great organ of English opinion, the foremost of English journals? The *Times*, which no one will accuse of partiality in this instance, says: "In the natural distribution of subjects, the history of enterprise, discovery, and conquest, and the growth of republics, fell to America, and she has dealt nobly with them. In the wider and multifarious provinces of art and science she runs neck and neck with the mother-country, and is never left behind!"

There are among us some persons who depreciate science merely through illiterate arrogance; there are some who, incited by superficiality, dislike it; there are some who regard it with an evil eye, because they think it is undermining the placid tranquillity they find in life-long cherished opinions. There are some who hate it because they fear it, and many because they find that it is in conflict with their interests.

But let us who are the servants of Science, who have dedicated ourselves to her, take courage. Day by day the number of those who hold her in disfavor is diminishing. We can disregard their misrepresentations and maledictions. Mankind has made the great discovery that she is the long-hoped-for civilizing agent of the world. Let us continue our labor unobtrusively, conscious of the integrity of

our motives, conscious of the portentous change which is taking place in the thought of the world, conscious of the irresistible power which is behind us! Let us not return railing for railing, but, above all, let us deliver unflinchingly to others the truths that Nature has delivered to us!

The book of Nature! shall not we chemists, and all our brother-students, whether they be naturalists, astronomers, mathematicians, geologists, shall we not all humbly and earnestly read it? Nature, the mother of us all, has inscribed her unfading, her eternal record on the canopy of the skies, she has put it all around us on the platform of the earth! No man can tamper with it, no man can interpolate or falsify it for his own ends. She does not command us what to do, nor order us what to think. She only invites us to look around. For those who reject her she has in reserve no revenges, no social ostracism, no *index expurgatorius*, no *auto-da-fé!* To those who in purity of spirit worship in her heaven-pavilioned temple, she offers her guidance to that cloudy shrine on which Truth sits enthroned, "dark with the excess of light!" Thither are repairing, not driven by tyranny, but of their own accord, increasing crowds from all countries of the earth, conscious that, whatever their dissensions of opinion may heretofore have been, in her presence they will find intellectual concord and unity.

MENTAL OVERWORK.

By ROBERT FARQUHARSON, M.D.

TO hit off the happy medium between over- and under-work is no easy task even to those who have the necessary knowledge, on the one hand, and the liberty to arrange their own scheme of occupation, on the other. But, for one person who is injured by doing too much, I quite believe with Dr. Wilkes that many may be found who are sustaining serious damage from not having enough mental stimulus. The listless vacuity in which so many of the well-to-do classes spend their lives, the want of any incentive to exertion, and the absence of any attempt at real thought which the wide-spread prevalence of ready-made opinions in our periodical literature directly encourages, must cause more or less degeneration of intellectual power. Under these conditions the brain gradually loses its healthy tone, and, although quite equal to the daily calls of a routine and uneventful existence, it is unable to withstand the strain of special sudden emergency, and, when a heavy load of work is unexpectedly thrown upon it in its unprepared state, then we see all the worst consequences of what may be called overwork develop themselves. It is no uncom-

mon experience to meet with cases in which damage has been done to the bodily constitution by indulging too recklessly in athletic exercises and active physical exertion when the muscles have become flabby and feeble from disuse. A man accustomed to sedentary pursuits takes suddenly to boating or running, or the horizontal bar, and, if he escapes straining his heart, he is certain to make himself stiff and uncomfortable. Or he has been told that there is nothing like Switzerland for reviving the faded Londoner, so, without the slightest attempt at preparation, he dovotes himself enthusiastically to climbing ice-peaks and traversing snow-passes; and, when his brief holiday is over, he comes back, worn and jaded, and astonished to find that the glacial air, which has proved so beneficial to many, has done nothing for him.

Now, the fault here lies in the want of proper preliminary training. Even as we do not prescribe quinine as a tonic until we have ascertained that the digestive functions of our patient are in good working order, so it is most improper for any one to attempt active muscular exertion without bracing up the previously-unused muscles by carefully-graduated exercise. And in mental operations the same analogy holds good. If the brain is not habituated to the constant gymnastic influence of steady work, it is liable to give way or suffer more or less injury from any sudden and spasmodic effort. If, on the other hand, however, its healthy nutrition is insured by the free supply of pure blood and the true balance between destruction and repair, we shall find ourselves in possession of an organ which will bear almost any amount of steady strain, so long as certain conditions are fulfilled. So long as a brain-worker is able to sleep well, to eat well, and to take a fair proportion of out-door exercise, it may safely be said that it is not necessary to impose any special limits on the actual number of hours which he devotes to his labors. But when what is generally known as worry steps in to complicate matters, when cares connected with family arrangements, or with those numerous personal details which we can seldom escape, intervene, or when the daily occupation of life is in itself a fertile source of anxiety, then we find one or other of these three safeguards broken down. Probably the man of business or the successful advocate cannot shake himself free from his business thoughts at night. Slumber becomes fitful and disturbed. The sympathetic system, unsettled by the mental strain, brings about various defects in nutrition; the appetite fails, and the vigor of the nervous tissues is no longer able to withstand the endless round; and then we meet with the sleeplessness, the dyspepsia, the irresolution, the irritability, and the depression, which are among the chief miseries of those who we are in the habit of saying are overworked.

Now, the *Lancet* has lately laid before its readers some interesting statements which would lead us to believe that damage is being done to many boys in preparatory schools by the strong competition

imposed upon them by the entrance-examination to the larger institutions, and by the ambition of their masters, who hope to derive profit and honor from their success. This is indeed a serious consideration, and the possibility of a large section of our most promising lads being thus mentally stunted in early life would demand instant interference did we deem the charge fully proved. Now, with all deference, I would venture to express my opinion, based on some experience, that, although we must not neglect so timely a warning of probable rocks ahead, there is no specific evidence of present injury. During my residence at Rugby I was in medical charge of several preparatory schools where the educational standard was very high, and where the success was proportionate when the boys came to be drafted off into the big school. I may truly say that no case was brought under my notice during the space of three years which I could in any way trace to overwork. And this I attribute to the perfect manner in which the counterbalancing conditions of health were sustained, the good food, satisfactory hygienic conditions, ample time for recreation and active sports, and frequent holidays. Boys of that age do not fret or worry over their work—they throw it off in their intervals of repose, sleep well, eat well, play well, and so do not suffer. Depend upon it, it would be little to the credit of any proprietor of a private educational establishment were he to neglect the laws of health, and send his boys home enfeebled and worn out from too heavy mental strain.

As regards the larger public schools the same remarks apply, and I met with very few instances at Rugby of any bad consequences from overwork; and in the three or four well-marked cases which came under my care I was enabled to detect some other equally operative cause which predisposed to the seizure. Thus one lad, ambitious of distinction both at classics and foot-ball, had undergone violent physical exertion while exhausted by study, and the supply of nerve-force, not being available for this double strain, gave way, and a sharp, feverish attack ushered in long-continued mental prostration. A second boy, who suffered from a precisely similar attack, had been sitting up late at night, and felt some anxiety about a future prize; and the third lad, who completes the catalogue, had also consumed the midnight oil to an undue extent. But, as a general rule, the typically healthy life and surroundings of our great public schools enable their inmates to withstand a much greater amount of work than lads brought up at home, who are often unduly spurred on, and who have not the healthful stimulus of enforced active exercise. Among this class I have seen a much greater proportionate extent of temporary break-down from the effects of mental exertion too long sustained and too little relieved.

Although the standard of the School Board is not very high, we may foresee a possible source of danger in forcing the minds of wretchedly feeble, ill-fed, and ill-housed children suddenly into edu-

cational grooves. I think I have seen an increase of headaches and nervous complaints among the children of the poor since compulsory attendance has been enforced, and would only wish to record the warning against attempts to make bricks too rapidly out of the straw which has fallen into our hands to mould for good or evil.

Coming to the universities, cases of overwork are, I imagine, more common there, for not only are the young men at a more sensitive period of life, but they naturally feel that to many of them this is their great opportunity—the great crisis of their existence—and that their success or failure will now effectually make or mar their career. Here the element of anxiety comes into play, sleep is disturbed, exercise neglected, digestion suffers, and the inevitable result follows, of total collapse, from which recovery is slow, and perhaps never complete. Others, again, endeavor in their last year to make up for the frivolities of the first two; but when Dr. Morgan takes up for us the history of the intellectual life of the universities in the same exhaustive way in which he has traced the statistics of their leading oars, I doubt not that we shall find that the indictment of overwork brought against them has also been much exaggerated.

But, although less common than is generally supposed, instances of this class of break-down do occur from time to time, and I should like to ask those who have devoted special attention to nervous diseases what is their view of the pathology of such cases as the following:

A student, or an artist, or the master of a public school, after a very heavy mental strain, suddenly gives way, and is seized with sharp illness, comparable in some degree to the old-fashioned brain-fever. On his recovery he takes a prolonged rest, and his general health is perfectly restored; he looks strong and hearty, and has even gained flesh, and so at last he thinks himself well enough to resume his duties. But it is found that, although he can do a little, anything like his old power of concentrated attention and steady application is gone, and if he tries to do a full day's work, he breaks down again in minor degree, and at last is obliged to content himself with taking only a very slight share in those occupations in which he used specially to excel, and in many cases his powers are never fully regained. With all the outward appearances of health, he well knows the very narrow limits within which he is now compelled to restrict his intellectual exercise. What, then, is the precise pathological condition here? Various diseases are also known to weaken the mental powers for long periods after convalescence is established, and of these scarlet and enteric fevers rank among the principal.—*Lancet.*

THE MEDICAL PROFESSION IN MODERN THOUGHT.[1]

By HENRY MAUDSLEY, M. D.,
PROFESSOR OF MEDICAL JURISPRUDENCE IN UNIVERSITY COLLEGE.

GENTLEMEN: It has devolved upon me this year to deliver, in accordance with prescribed custom, the introductory lecture to the course of systematic instruction upon which you are about to enter. At the outset I am free to confess that I have been not a little perplexed and troubled about what I ought most fitly to say; like many of my predecessors in the office, I have found the choice of subject beset with difficulties, and I have small hope that I can say anything to redeem the usual barrenness of the occasion. It is just twenty-five years since I, sitting where one of you now sits, listened to my first introductory lecture from the lips—mute, alas! now forever—of one whose pure and gentle nature attracted in no common measure the esteem, the respect, and the affection, of all who knew him. I mean the late Dr. Parkes. It is an extraordinary, almost an unparalleled, thing to say of any man, that no one who heard mention made of his name ever heard an ill word said of him; but I believe that this was strictly true of Parkes. His life, lovely and of good report throughout, was indeed a practical refutation of the saying, "Woe unto you when all men shall speak well of you." If I could sketch in striking outline the features of his character, and set forth justly the pure course of his life—showing with what patient industry and entire sincerity of insight he worked in scientific inquiries, how upright he was in all his ways, and how kindly considerate to others: how he lived, and how, his work faithfully done, he died—I should probably give you an inspiring and most useful introductory lecture; for I should present to you a noble example, the labor to imitate which would be an excellent scientific and moral training. But that has been done with more or less completeness by various persons, though not always, perhaps, with the discrimination which one would wish to see shown in the appreciation of such a character. It is a very amiable wish to say everything good of a man when he is silent forever, and the vocabulary of flattering words is apt to be exhausted in the endeavor to gratify this feeling, the effect sometimes being that the actual features of the character are blurred, and something which is intended to be very perfect, but which is very unreal, is produced. It seems to me that the distinguishing characteristic of Parkes, that by which mainly he was what he was, was not so much originality or height of intellect (in this others have equaled or surpassed him) as the height of his moral stature—in this

[1] Introductory lecture delivered at University College, London, October 2, 1876.

perhaps he has hardly ever been surpassed; and that the grand lesson to be learned from the extraordinary esteem and affection which he inspired, from the infection of earnestness and sincerity which spread from him, and from the elevating influence which he exerted upon those who were brought into close converse with him, is a lesson which the history of human progress through the ages teaches too, and which needs much to be had in remembrance in these days of the glorification of science. It is this: that great as is knowledge, the moral nature is greater still; that the impulses of evolution which move the world come not from the intellect, but from the heart; that he who would work upon the hearts of others must speak to them from the heart; that everywhere and always we have to recognize the predominance of the heart over the intellect.

Perhaps if I could recall vividly the thoughts and feelings of my mind when sitting there twenty-five years ago, and compare, or rather contrast, them with my thoughts and feelings now, I might extract from the comparison the essence of a quarter of a century's experience of life, and impart to you what it will probably take you a quarter of a century to acquire. But I am doubtful whether that would not be to do you a great disservice, for I could hardly fail thereby to take much heart out of your hopes, much ardor out of your enthusiasm, much energy out of your exertions. Moreover, I feel pretty sure that what I could say, however wisely it might be said, would not be of the least use to you. Neither nations nor individuals profit much by the experience of other nations or of other individuals; they must go through their experience for themselves, learning through suffering, succeeding through blundering, attaining to the calmness of wisdom through the fevers of passion; and many times only when opportunities are gone, and their consequences in irrevocable operation, is it seen perhaps how much better use might have been made of them. No doubt there is wise purpose in this inability of the young to take home and assimilate the experience of those who are older; for I know not how they could preserve that enthusiasm and freshness of spirit which make life itself a joy, and beguile them to pursue with eagerness its aims, were their illusions destroyed, as illusions one after another are destroyed by experience. In the full stream of its young energy life is too little conscious for reflection; to live is happiness enough; in its later stages more and more, as the heart is applied to know wisdom, is it felt to be vanity and vexation of spirit. This may seem a hard doctrine, but it is true; it has been the experience of the greatest sages of all times; it is the central thought of the great religious systems of the world.

Let me pass, however, from reflections which, if pursued, might tend to dishearten rather than to hearten you, and endeavor to show you that, as things go, you have made a good choice of a profession for your life's work. I should be thought to have ill discharged the

function of introductory lecturer by preaching a gospel of pessimism, and inoculating you at the outset of your career with a despair of the littleness of life. Whatever the motive which has made you choose the medical profession as your life-career—and I suppose this has in most cases been the advice or example of others, or perhaps some quite accidental influence; for it is a startling consideration on what little circumstances the great issues of life often turn—you will not, I think, ever have cause to regret your choice if you look to the higher aim of it, and to that which is the proper end of human life. But on that condition only. It is not a profession which one who is ambitious of worldly distinction, or eager to accumulate much riches, should choose. You might, with prudence and industry, get vastly richer on the Stock Exchange or in commerce in a short time than you will probably after the labor of a long life in medical practice; and if you would aspire to gain a peerage or other ornamental thing of that kind, you would have done better to have gone into the army, and to have set before you as an aim, not the saving but the destruction of life; or to the bar, and have sold the highest exertions of your intellect to advocate the cause, whether the cause of the oppressor or of the oppressed, for which you were retained. Peerages don't come our way, and I am heartily glad they do not, for I much fear that there would not be the strength of mind to reject them; that a pitiful social ambition might tempt us to spoil the simple intrinsic nobility of our vocation with the outworn decorations of a childish stage of human progress. If medical practice be pursued as a mere means of money-getting, assuredly it causes the deepest demoralization of him who so uses it, as best things turned to basest ends breed the greatest corruption. He who deliberately applies himself to take the utmost advantage of the suffering and the feebleness of humanity, coming to him for aid in its anguish and its utter helplessness, in order to make his profit—and we may hope there are not many creatures of that vileness in the profession—may have large success in his low aim, but he discovers a meanness and a degradation of nature which are a grievous shame to his kind, and which devils might almost disdain.

But if you look to what is the true end of knowledge and work—to relieve the suffering and to minister to the comfort of man's estate, to lessen the sum of human sorrow on earth—you have chosen a profession which yields the fullest satisfaction to your aim and the largest scope to your work. We learn in order to act, the end of all knowledge being action; and the end of all action is to promote the welfare and the progress of mankind upon earth. In no profession are the opportunities of doing this good work so great and constant as in ours; to the least of us, as to the greatest, occasions of tender sympathy and patient help occur every hour in the daily routine of our work; and no profession, therefore, rests so little for appreciation upon any adventitious circumstance of time or place, or so little needs

extraneous titles of honor to give it dignity and respect. Put a doctor in the midst of the wildest savages, and they will respect the "medicine-man," when the lawyer's fluent sophistry and the preacher's pathetic eloquence would not gain them consideration, or even save them from death. Livingstone passed unharmed and esteemed among the savage tribes of Africa under the protection of his medical skill; and Christ himself cultivated the character and functions of a healer of disease, not only because in that capacity he went about doing good, but probably also, as De Quincey surmised, for the secret reason that he thus disarmed the jealousy and suspicion which the ruling authorities might otherwise have felt of the crowds which he drew about him. When the mighty fabric of the Roman Empire, penetrated by internal decay, at last fell to pieces under the successive assaults of the Goths, and the Vandals, and the Huns, many thousand persons were, as Gibbon tells us, taken captive and distributed through the deserts of Scythia; and it is interesting to note what was the relative value of persons under these circumstances. "The skill of an eminent lawyer would excite only their contempt or their abhorrence. The vain sophist or grave philosopher who had enjoyed the flattering applause of the schools was mortified to find that his robust servant was a captive of more value and importance than himself. But the merit of the physician was received with universal favor and respect; the barbarians who despised death might be apprehensive of disease." So long as man deems it the most important thing in the world to him that he should go on living—and he does that commonly as long as he is alive—so long will he hold in favor and esteem him whom he believes able to prevent or to mitigate the suffering of disease, and to keep at bay "the last enemy," death. It has always been so. "Honor a physician with the honor due unto him for the uses which ye may have of him; for the Lord hath created him."

Having seen how good a thing is the direct work of relieving suffering by medical art, let me now go on to point out that the training through which you go in order to fit yourselves to do this is excellently well adapted to make the most of your intellect as an instrument of knowledge. It seems to me that no education which is given anywhere, taking it all in all, is better than that through which it is necessary to go in order to become a thoroughly accomplished physician. You are brought into direct contact with the facts of Nature, face to face with them from the beginning of your course; step by step you advance in the practice of observation and reflection, from more simple to more complex phenomena, and so you learn to make the order of your ideas conform gradually to the order of Nature. That is real instruction; moreover, it is instruction at first hand. In intercourse with Nature, sophistry and pretense avail nothing; sincerity, and humility, and veracity of mind, are essential; we must learn patiently her laws, and, learning, obey them, or we ourselves, our con-

temporaries, or our posterity, will suffer infallibly from their violation. There is no possibility of hoodwinking those eternal laws which, in our dealings with them, never make a mistake and never overlook one, never forego an advantage, never shrink to exact retribution, never feel remorse. When a person leaves college with a very respectable knowledge of Greek and Latin authors, and with little or nothing more than that, it seems preposterous that he should think himself an educated person. If he has learned nothing about the stars above his head and the earth beneath his feet; nothing about the nature of the air which he breathes, of the water which he drinks, of the food which he eats; cannot tell why water rises in a pump, or how a man breathes, and why he dies if he cannot get air to breathe; knows nothing whatever of the laws of the world in which he lives and of which he is a part, he is surely a profound ignoramus, notwithstanding that he may be able to make indifferent Greek or Latin verses. I would not for a moment undervalue the priceless benefits of a knowledge of Greek and Latin authors; on the contrary, I am sure that a study of the works of these great minds of antiquity, full as they are of the rich stores of human observation and thought, expressed in the most chaste, concise, and finished language, produces a discipline of intellect and a refinement of culture which can be got in no other way, and the loss of which in youth nothing gained afterward will ever entirely compensate for; but I am sure also that if Plato or Aristotle, or any of those great thinkers of antiquity, were to live again now, he would look with amazement and compassion, if not with contempt, on men who are content that education should consist in studying only the writings of the past, in utter neglect of the wonderful works of Nature to which the later ages of mankind have gained access, and of the vast stores of knowledge which have been gradually accumulated by the patient labors of successive generations of men. He would be apt, I think, to say something of this sort: "Good Heavens! we lived more than two thousand years ago; have you in all that time gained no new experience of men and things which it would be well to make an essential part of the intellectual culture of your children? is it education enough for life now to let them learn from us what we thought of men and things more than two thousand years ago, and to train them in a study of the structure of our dead language?" To state the matter so, sufficeth to expose its absurdity.

Now, the training of a medical man, when thorough, is admirable in this respect, that it follows the order of Nature, beginning with the less complex and rising to the more complex sciences, using the lower as a ladder by which to mount up to the higher. Coming to his work, as he certainly should do, with a fair knowledge of mathematics and physics, he proceeds to the study of chemistry, and passes on thence to the study of physiology; so he lays deep and firm the scientific groundwork for the study of the disorders of the structure

and functions of the body, which is to be his ultimate special work. Without the foundations of the prerequisite studies he will not be a thoroughly well-grounded and cultivated physician, who may be relied upon to perfect his knowledge by experience through life, although he may no doubt be a fair practitioner in the routine which he has been taught, or, if he devotes himself to surgery, skillful as a mere operator. A knowledge of the simpler and more general science is an essential prerequisite to the study of the more complex and special science. Physics lie beneath chemistry; in physics and in chemistry we search for those intimate operations of matter which lie at the foundation of physiology; and physiology in its turn is essential to the construction of the more complex science which is concerned with man in his social relations—that is, sociology. And I may observe, by-the-way, that psychology, which is an important study for the man who has to put right the disorders of the minds and bodies of his kind, demands not only a thorough knowledge of physiology, but observation, also, of man in his social relations. Each science rests upon the one below it, but reflecting the increasing complexity of Nature as we rise from the movements of masses to the movements of molecules of matter, and to the combinations and relations of atoms, from dead again to living matter, from the simplest forms of life to complex organisms, and from organisms to the social union of organisms, contains in ascending scale something more than the science below it—something which constitutes its autonomy as a science. Physiology being placed in this scale, as you perceive, between chemistry and sociology, is on that account a most instructive study at the present time, when chemistry has made great progress toward scientific exactitude, and when the cultivation of the new field of social science is just being entered upon; there is no science, in fact, which yields such rich promise of large discoveries in the immediate future, and no science the discoveries of which, when applied to human needs, will do so much to lessen physical suffering. Fortunate are you, then, in the training which prepares you for the study, and in the lot which at this particular era has fixed your work in the pursuit, of a science which promises so great an abundance of good fruit.

One warning I would stop a moment here to urge. While recognizing the subordination of the sciences, we ought not to overlook the fact that all the sciences are at bottom artificial divisions; that the world is not divided rigorously into those different domains which we call physics, chemistry, physiology, and the like; that we make the divisions for our convenience according to the complexity of the phenomena, not because we discover them in Nature. Nature is one and continuous, and takes not the least notice of the arbitrary divisions which we find it necessary to make. It would seem a very obvious distinction between plant and animal; and yet if we push our

investigations into that border-territory of Nature where animal and vegetable life touch, we meet with so-called monads—the *Heteromita*, for example—which may be referred with equal justice to either kingdom; there are organisms which we think vegetable, having characters which we call animal, and organisms which we call animal, having characters which we think vegetable; there is, in truth, no line of demarkation, but instead an insensible series of gradations, and no man can say where the one kingdom ends and the other begins. In like manner, notwithstanding the seemingly gross and palpable distinction between living and dead matter, any one who sets himself to work to find out where life begins will be hard put to it to draw a line of separation, and more hard put to it when called upon to make good his division. Man himself, much as he makes of himself, is not separated from the rest of Nature by an impassable gulf; he modifies Nature largely, it is true, but the art by which he does that is Nature; he is a part of the order thereof—the latest product of the evolution which went on for countless ages before he appeared upon earth, which is going on now in his progress, his knowledge and his moral feelings being agencies in the process, and which, for anything we know, will go on for countless ages after the earth, which he has ceased to replenish and subdue, has fallen into the condition in which the moon now is, and rolls on its solitary way through space, a cold and desert globe, the tomb of all human aspirations, sorrows, sins, and achievements. In making use, then, of the arbitrary divisions of our sciences, we ought never to lose hold of the actual unity and continuity of Nature; never to overlook the fact that there is not a single truth in any science which has not its essential relations with the truths of all sciences; never to forget that the least things and the greatest are indissolubly bound together as equally essential elements of the intimately connected and mysterious whole which we call the universe. It may seem a fanciful saying, but there is a truth in it, that you cannot utter an exclamation, strike a note on a piano, move a grain of sand from its place, without affecting the entire universe.

Now the systematic training of the mind in conformity with the order of Nature, through patient observation and careful induction, the knowledge of Nature which is got by becoming, as Bacon says, her servant and interpreter, is a tedious business. Men, therefore, have gladly shirked it; they have found it much easier to attribute phenomena to some metaphysical entity which they have created out of a mental abstraction, or to invoke a supernatural cause to account for them, than to find out the explanation. In consequence of this habit of mind, which has had large operation in the past, a body of doctrine has grown up which, having had its day, is now fast becoming effete, but which men will not willingly part with—doctrine comparable, if I may use a physiological comparison, with those organs which, like the thymus gland, have their uses at a certain stage of

the body's development, but afterward, having no longer any function, undergo atrophy. Moreover, men have not only shirked positive inquiry from indolence, but have hated it from hostility. They dread the thought of being shown to be one with Nature, and repudiate with abhorrence the suggestion that their bodies and minds will ever receive scientific explanation; as if their bodies and minds would be degraded to something quite different from what they are by being understood like other natural phenomena and described in terms of scientific thought. The supposition strikes them as something like a blasphemy against the nobility of their nature. Hence there is a deep-rooted instinctive hostility to the science that has to do with man, which you will have to take account of in your careers—an hostility which has found partial expression, I think, in the anti-vivisection agitation. There was more in the fierceness of that agitation than a laudable feeling of compassion for the animals—an intensity of acridity betraying another origin. There was the energy of fear and hatred—fear and hatred of the science which threatens the dethronement of man from the pedestal of conceit upon which he has placed himself, and the destruction of some of his traditional beliefs. But a little reflection might serve to prove to those who are moved by these hostile apprehensions that they are possessed with an unreasoning fear, and are disquieting themselves in vain. Let them look beyond the dark circle of their self-love, and they will see that what is good in old creeds does not perish; that, although old forms vanish, as generations and nations pass away, that in them which gave life to them does not pass away, but puts on new forms and survives, as new generations and nations follow and carry onward the work of progress. Better would it be for them to seek for and foster the good which survives than to lament and defend the old which is corrupt.

Certainly science has not been careful to avoid occasions of offense in its progress, and of its method and pretensions its votaries have sometimes written in a strain which justly provokes scorn. While proclaiming, then, the praises of observation and induction, and enforcing the value of a mental training which is obtained by studying Nature after that method, let me interpose a few words of qualification, in order that I may not be misunderstood. I cannot help feeling that a great deal of questionable doctrine has been propounded concerning the so-called method of induction which science is enjoined rigidly to pursue, and that Bacon would have been aghast had he seen the absurdity which some persons in these days describe as his method, and the imbecile procedures of some of those who believe that they are following it. They talk, in fact, of the method of observation and induction as if it were something to conjure by; a mechanical process of knowledge-getting which rendered superior mental capacity unnecessary; a sort of intellectual ladder by which the most stupid beings, if they only planted it properly, might mount up into the

highest places of knowledge. That was not Bacon's notion of it: he perceived clearly enough that a man does not see with his eye, but through it; that seeing in the sense of observation is impossible unless there be behind the eye the intelligence to interpret what is presented to it. The simplest act of perception is indeed more than a mere matter of sense; it is an actual induction or inference in which an important element is contributed by the mind; you cannot look at an ox or an ass, and know either of them to be what it is, without making an induction—can't see, in fact, until you are trained to see. Scientific observation and experimentation—and experiment is only observation aided by artificial means—may be carried on to the last hour of your lives without any result of the least value if you have not a mind trained to interpret. Of what use is it to torture Nature by strange experiments if you don't understand her language? You might sacrifice a hundred dogs or cats in cruel experiments, and be not a whit wiser at the end of your awful labors. Nature does not vouchsafe an answer to a scientific inquiry unless the intelligent question be put, and the precise experiment made, as Bacon insisted, *ad intentionem ejus quod quæritur;*[1] and it is impossible to put the definite question, or to make the precise experiment, unless there be a prudently-formed hypothesis in the mind—that is to say, an hypothesis based upon previous careful training in observation of Nature's processes and sound reflection upon them. The mind must be informed by patient and sympathetic intercourse with Nature; it is enabled then to make new adjustments by means of the knowledge which it has gained through past adjustments—to frame a new and true theory applicable to new experiences by reason of being stored with sound theories derived from past experiences. We shall do well, then, not to be too much intimidated by what is sometimes said or written in praise of mere observation of so-called facts, and in dispraise of theory, or imagine that any facts can be truly observed, or any science prosecuted with success, unless the well-trained mind coöperates with the senses. As I have said elsewhere, "That some declaim so virulently against theory is as though the eunuch should declaim against lechery; it is the chastity of impotence." Happy is the observer who, when he sets to work, has a good theory in his mind. The mischief is when men theorize who have not been trained in habits of accurate observation, or, I might go a step further and say, who have not inherited from father or grandfather in the foundations of their nature the lines of veracity of observation and thought on which to develop; for when one notices how persons of a certain eager temperament go on discovering facts which are no facts, and, notwithstanding that they are brayed in the mortar of an annihilating criticism, are not in the least benefited by the discipline, one cannot help feeling that the observer, like the poet, is born, not made.

[1] With special reference to the point under investigation.

But it is time to return to the direct line of my argument. From what has gone before, it should appear at what an excellent place of advantage the order of studies for the medical profession is adapted to place you; how wisely it is arranged to train the mind for sound reflection upon those most complex phenomena of Nature with which the medical man has to deal—the phenomena of life in health and in disease; and how sadly wrong in theory and mischievous in practice he is likely to be who neglects to lay well the foundations of his mental training. If no practical result were to follow a medical education, if it were not pursued, as it is, for the purposes of the medical art, I believe that one who aspired to fit himself best to understand the world in which he lives, and the men with whom he has to do, could not do better than go through it; for it would be an excellent foundation on which to build afterward. The study of man cannot be undertaken with any satisfaction, or carried out with any completeness, except through a previous study of the nature of which he is the present culmination; it is certainly not possible to enter the chamber of the mind without passing through the antechamber of the body; and we cannot understand the body unless we understand a good deal of the processes and laws of Nature which lie beneath biology. So far, then, Mr. Lowe appears to be right when he regrets, as he is in the habit of doing, that he was taught so much classical knowledge and no science when he was educated, and contrasts the disadvantages under which he labored with the advantages which each student at a middle-class school now enjoys. Newspaper critics think that he is making jokes or firing off paradoxes, and would seemingly rather have Mr. Lowe as he is than Mr. Lowe as he might or would have been; but I am disposed to think that Mr. Lowe's insight has enabled him to see what his critics quite fail to see—that the statesman who has to deal with the relations of men to one another in the world would be better qualified for his work if he had a good fundamental knowledge of the laws of man's nature and constitution, and of the laws of the world in which he lives. The scientific statesman—when we get him—will hardly deem it his highest achievement to shrink scared from the grasp of a principle, or his supreme privilege and merit to wait patiently to catch the fitful gusts of an ignorant public opinion.

The application of the principle which I have been enforcing, of learning to know man through Nature, the thorough knowledge of his environment, and of those of his relations to it which constitute his life, must clearly be the foundation of a scientific medicine. Here, as elsewhere, prevision for the purposes of action is our aim; we observe and infer in order to foresee, and, foreseeing, to modify and direct; we conquer by obeying, gaining a knowledge of the phenomena of living beings in order to make ourselves masters of them, just as by a knowledge of physics and chemistry we gain a mastery over the phenomena of physical Nature. It is impossible to treat a sick person,

except in the most lamely empirical fashion, without a knowledge of the properties of the organism and of its relations to its environment; for our medical function is to remove the disorder of these relations, which is disease, and to restore the harmony, which is health. In past times it has been too much the practice to treat the body as if it were an entirely independent kingdom, without regard to its essential relations with surrounding Nature, and to try to drive out the enemy which was supposed to have taken possession of it, by pills and potions, as barbarous nations try to drive him out by charms and ceremonies. Now, however, in the recognition of the intimate and constant relations between the organism and its surroundings, we are awaking to juster views of our duties as observers, and of our work as curers of disease; but it is because of the absence yet of anything like exact knowledge in this respect that medical practice is defective, tentative, empirical, often mere guess-work, and that the most experienced physicians, waiting patiently on Nature, aim to do the least harm by the drugs which they employ.

But we are perceiving more clearly, day by day, a larger application of this principle of looking to the relations of man, to what is around him as well as to what is within him, in the fulfillment of the great purpose of preventing disease. It is in this direction that the future course of medicine lies clearly open, and to this end that we must work; it will rise to the true height of its great vocation when it watches over communities, and ministers to the welfare and development of the race. I am apt to think that we shall attain to earlier and larger success in preventing the diseases of communities than in curing the diseases of the individual, as men who had been seeing heavy bodies fall to the earth every moment of their lives discovered the law of gravitation for the first time when they began to observe the grand general motions of the heavenly bodies. Indeed, we have already had encouraging success. Look through the yearly death-list of this great city two hundred years ago, and you will find a large proportion of deaths ascribed to diseases which have now been robbed of their sting, if they are not quite extinct. Many persons died then, as "that chief of men," Cromwell, did, from ague. Where is the mortality of ague now? Ague has disappeared with the disappearance, through better drainage, of the damp fogs which occasioned it, as ghosts and other superstitions have vanished with the disappearance, before the light of knowledge, of the fogs of ignorance in which they were engendered. Bloody-flux or dysentery seldom occurs now in England, and is more seldom fatal, but it caused many deaths two hundred years ago. The ravages of small-pox were then terrible, hosts of victims being carried off by it, and many persons who escaped death bearing its marks in blind eyes and hideously-scarred features; but I think we may foresee a time when, Keighley guardians notwithstanding, small-pox will no more afflict a prudent people. Plague,

scurvy, and spotted fever, each of which then claimed regularly its yearly tribute of victims, are becoming almost diseases of the past, and one needs not a prophet's imagination to foresee a time when cholera, scarlatina, fever, phthisis perhaps, and other diseases, will be no more; when preventive medicine shall have reached such a degree of perfection that the occurrence of epidemic disease will be felt as a gross reproach to the community, and when there will be comparatively little for the practitioner to do in the treatment of particular disease. It is unfortunate truly, as it is sadly unseasonable, that just when we see before us this fairer prospect, and when an encouraging beginning of progress has been made under the auspices of Mr. Simon and his well-organized staff, he should have been driven from office and his office abolished. But one instance more of the difficulties with which progress has to contend from the selfish intrigues and obstructive apathy of mankind!

You may be disposed perhaps to smile at my outlook as fancifully bright, and befitting only the imaginative flights of an introductory lecture. From the beginning, it may be said, men have, through unrestrained indulgence of their passions, generated disease, and however pure their surroundings may be made, they will go on doing the same thing: were a clean sweep made of all disease from the face of the earth to-morrow, they would breed it afresh before to-morrow's morrow. No doubt, as they are constituted and trained at present, they would be apt to do so; but one may hope that the medical science of the future—and here I would carry your imaginations a little way with me—will have a great deal to say in the way of instruction respecting the highest concerns of man's nature, and the conduct of his life; that it will enter a domain which has hitherto been given up exclusively to the moral philosopher and the preacher. I don't propose or suppose that we shall ask these gentlemen to step down from their platform, saying to them something of this kind: "You have been preaching wisdom and goodness of conduct for some thousands of years, and you haven't made much of it. Certainly one result thus far is striking enough: that men are devoting their eagerest energies to making the most destructive guns, and are conferring their greatest honors and applause on those who use them with the most destructive effects. For months, until quite lately, the soil of Eastern Europe was deluged with blood, shed amid unspeakable atrocities, in an entirely needless war, which your statesmen, presumably the highest products of the culture of your epoch, could or would do nothing to check. Stand aside, then, and let us try our method." To speak so would be as foolish as it would be arrogant; but we may perhaps, without undue presumption, promise them that, if they will learn and use the results of our method, they will have a deeper and more stable foundation in the constitution of human nature for their teaching than they have now, and will add much to the effi-

cacy of it by enforcing motives which will touch more keenly the springs of human conduct than those which they present. Now let me indicate very briefly, as must needs be, the method by which medical science is to advance to take possession of this higher ground.

Starting with the trite maxim that before we can act we must learn, it is obvious that, before we can teach men to act with more wisdom than they have done in the past, we must give them a better knowledge of their own nature and relations than they have had. This we propose to do by the patient and steadfast application of the method of observation and induction, which has served us so well in the subordinate branches of science, to the highest phenomena of man's being—his thoughts, feelings, and conduct. The problem is the same here, in fact, as in the lower sciences—to observe in order to foresee, and to foresee in order to modify and direct; and the method is the same. Admitting, as I see not how we can help doing scientifically, that a process of evolution has gone on in Nature, and that man, as he now is, is a product of the past carrying on this process in his progress to a higher purpose in the future, it is a natural conclusion that he must, as a part of Nature, be studied by the same method as the rest of Nature. We have to search back and find out how he came to be what he is by looking to the historical evolution of the race from its earliest known conditions, and by tracing in the development of the organism the operation of laws which we discover at work under less complex conditions in the rest of Nature. When we do that, we find the best reason to believe that the highest faculties of his mind, his intellect, and his moral feelings, have not been implanted ready-made in his nature at any period of its history, but have been the slowly-won results of the accumulated experiences of the race transmitted by hereditary action: that is the lesson which observation and induction, applied to the investigation of the origin and development of man's higher nature, teach with an authority which cannot be gainsaid from any standpoint of positive knowledge. I could have wished, had I had time, to have shown you how some phenomena of mental disease, which may be looked upon in this relation as instructive experiments of Nature made for us in a domain where we cannot make them for ourselves, confirm the induction which has been reached by observation of human development, both in the individual and in the race. But I must leave that unsaid, and restrict myself to the conclusion as regards conduct which results from the acknowledgment that the latest and best acquisitions of man have come to him by a process of ordinary development through the ages. For the problem of to-day is truly no longer the schoolmen's much-vexed question of the origin of evil, but the question of the origin and growth of good. Our plain duty is to find out the laws which have been at work in that process, and to continue it—to carry on, by deliberate method, with conscious purpose, the development

which has been going on through past ages irregularly and blindly. The time, in fact, has come when mankind should awake to the momentous reflection how great is the power which it may exert over its own destiny, and to the resolution methodically to use it. In fulfilling this paramount duty, upon whom will the function of inquiry and instruction immediately rest, but upon those who make the laws of vital development and function their study, and the application of the knowledge to further the well-being and development of the organism their work? Clearly, the medical investigator need not lapse into despair because he has no new conquests to make.

You will not be long in practice before you will have many occasions to take notice how little people ever think of the power which they have over their own destiny and over the destiny of those who spring from them—how amazingly reckless they show themselves in that respect. They have continually before their eyes the fact that by care and attention the most important modifications may be produced in the constitution and character of the animals over which they have dominion—that by selective breeding an animal may almost be transformed in the course of generations; they perceive the striking contrast between the low savage with whom they shrink almost from confessing kinship and the best specimens of civilized culture, and know well that such as he is now such were their ancestors at one time; they may easily, if they will, discover examples which show that by ill living peoples may degenerate until they revert to a degraded state of barbarism, disclosing their former greatness only in the magnitude of their moral ruins;—and yet, seeing these things, they never seriously take account of them, and apply to themselves the lessons which lie on the surface. They behave in relation to the occult laws which govern human evolution very much as primeval savages behaved in relation to the laws of physical Nature of which they were entirely ignorant—are content with superstitions where they should strive to get understanding, and put up prayers where they should exert intelligent will. They act altogether as if the responsibility for human progress upon earth belonged entirely to higher powers, and not at all to themselves. How much keener sense of responsibility and stronger sentiment of duty they would have if they only conceived vividly the eternity of action, good or ill; if they realized that under the reign of law on earth sin and error are inexorably avenged, as virtue is vindicated, in its consequences; if they could be brought to feel heartily that they are actually determining by their conduct in their generation what shall be predetermined in the constitution of the generation after them! For assuredly the circumstances of one generation make much of the fate of the next.

In the department of medical practice in which my work mainly lies I have this amazing recklessness strongly impressed upon me; for it occurs to me, from time to time, to be consulted about the propri-

ety of marriage by persons who have themselves suffered from insanity, or whose families are strongly tainted with insanity. You will not be surprised to hear, I dare say, that I don't think any one who consults me under such circumstances ever takes my advice except when it happens to accord with his inclination. The anxious inquirer comes to get, if he can, the opinion which he wishes for, and, if he does not get that, he goes away sorrowful, and does just what his feelings prompt—that is, gets married when he has fallen in love, persuading himself that Nature will somehow make an exception to inexorable law in his favor, or that his love is sufficient justification of a union in scorn of consequences. Certainly, I have never met with so extreme a case as I chanced to light upon in a book a short time ago. "I actually know a man," says the author, "who is so deeply interested in the doctrine of crossing that every hour of his life is devoted to the improvement of a race of bantam fowls and curious pigeons, and who yet married a mad woman, whom he confines in a garret, and by whom he has insane progeny." But I have met with many instances which prove how little people are disposed to look beyond their immediate gratification in the matter. If it were put to two persons passionately in love with one another that they would have children, one of whom would certainly die prematurely of consumption, another become insane, and a third, perhaps, commit suicide, or end his days in workhouse or jail, I am afraid that in three cases out of four they would not practise self-denial and prevent so great calamities, but self-gratification, and vaguely trust "the universal plan will all protect!"

Those who pay no regard in marriage to the evils which they bring upon their children, or in their lives to the sins by which the curse of a bad inheritance is visited upon them, may plead in excuse or extenuation of themselves the vagueness and uncertainty of medical knowledge of the laws of hereditary action. We are unable to give them exact and positive information when they apply to us, and they naturally shelter themselves under the uncertainty. Were our knowledge exact, as we hope it will some day be, we could foretell the result with positive certainty in each case, and so speak with more weight of authority. It is one of the first and most pressing tasks of medical inquiry to search and find out the laws of heredity, mental and bodily, in health and in disease, and, having discovered exactly what they are, to apply the knowledge purposely to the improvement of the race—that is, to prevent its retrogression and to promote its progress through the ages. I see no reason to doubt that by discovery of these laws and intelligent practical use of our discoveries we might in the fullness of time produce, if not a higher species of beings than we are, a race of beings, at any rate, as superior to us as we are superior to our primeval ancestors; the imagination of men seems, indeed, in the gods which they have created for themselves, to have

given form to a forefeeling of this higher development. But I will not pursue this pregnant matter further now; I have touched upon it only for the purpose of illustrating the large scope of the medical work of the future, which is to discover those laws which have been in operation through the past to make man the superior being which he is, and to determine his future action in intelligent conformity with them; not only to cure disease of body and mind, as it has aimed to do in the past, and to prevent disease, as its larger aim now is, but to carry on the development of his nature, moral, intellectual, and physical, to its highest reach.

So much, then, concerning the three topics on which I have proposed to myself to discourse in this lecture—namely, the nobility of your direct function as healers of disease, the excellence of the method of medical study as a means of intellectual and moral training, and its fruitfulness in benefits to mankind, and the grandeur and the reach of its aspirations for the future. Let me hope that I have, in fulfillment of my design, said enough to satisfy you that you have made a good choice of a profession for your life's work. Having chosen, it remains only that you should justify your choice by your work, so that it may be said of each of you, when his long day's task is over and the night has come, that he was in his right position in the world, and made a right good use of it. Life has its three stages —youth, manhood, and old age; let it be your anxious care now, in the first stage of joy and hope, so to pass the second stage of work and duty that the last stage may not be a long regret.

I will ask your indulgence only for a few minutes more, while I detain you for one or two final reflections of what I may call an inhibitory character. In pursuing resolutely the course of scientific inquiry which I have indicated, it must needs be that offenses sometimes occur, for we can hardly fail to come into collision with some of the prejudices and traditions of mankind. I do not know how it is possible, for instance, to prosecute the physiological investigation of mind to its farthest reach without shaking the foundations of the metaphysical notions which have been held concerning it and its functions; and with the fall of these notions, long cherished of mankind, other notions that are bound up with them may totter to their fall. But, if this must be, we shall do well to acknowledge it more in sorrow than in anger. Let us not rush with eager fury and exultant clamor to the work of destruction; it behooves us, as products of the past, who will one day ourselves constitute the past, to deal gently and even reverently with it. We cannot break with it if we would, nor should we if we could. The very language which we use we owe to the slow acquisitions of generations which have preceded us; we cannot compassionate or contemn them except in words for which we are indebted to them. There is hardly a word I have used in this lecture which, were its history searched out, does not mean

generations of human culture to which we are heirs. Seems it not, then, a wicked, almost a sacrilegious, thing to hasten with eager gladness to repudiate the past to which we owe everything, and to exult over the ruins of its beliefs? It is as if a son should rejoice over his father's feebleness, uncover his nakedness, and make scorn of his infirmities. As he who has been the best son is in turn the best father, so the generation which guards with respect the good which there is in the past, and puts gently aside that which is effete, will make the most stable progress in its day, and transmit the best inheritance to the generation which follows it. No doubt in the future, as in the past, the knowledge of one period will sometimes appear foolishness at a more advanced period of human evolution—the truth of one age become the laughing-stock of the next; but we may profitably reflect that decaying doctrine had its use in its day, and it may teach us modesty to consider that much which has its place in our mental organization now, and is serving its proper end in the development thereof, will one day probably be put aside as obsolete belief. Let it be our prayer that when that day comes, and this generation comes up for critical judgment as an historical study before the tribunal of posterity, it may be justly said of it that it has done as much for the progress of mankind as some of the generations upon which the wisest of us look back, perhaps, with indulgent compassion, and the unwise among us with foolish scorn.

There is nothing in the attitude of modern society toward science, cold and suspicious as it may sometimes be, which necessitates or warrants an arrogant, defiant, and aggressive spirit of hostility on its side. No great courage is required nowadays to declare a new truth, however hostile it may be to received belief, nor is any serious suffering entailed by the declaration; there is no need, therefore, for a scientific man to put on the airs of a martyr. He is a very little martyr who is persecuted only by the pens of unfriendly critics, and rather a pitiful object when he sits down by the wayside, and calls upon all them that pass by to behold and see how hardly he is used. It was very different when Science first made its voice heard; when, under the cruel persecutions of the Inquisition, Galileo unsaid with his tongue truths which his heart could not unsay, and that grand figure in the noble army of scientific martyrs, Giordano Bruno, went calmly and resolutely to the stake rather than utter one word of retractation. The saddest contemplation in the world, perhaps, is that of the brave who, like him, have died fighting in the battle for the cause that seemed to perish with them; whose lives of suffering and sore travail have set, often through cruel tortures, in black clouds of gloom which no ray of hope could penetrate. Theirs was not the laurel crown of victory after the agony of the struggle; no popular applause, no encouraging shout, greeted their ears as they sank down exhausted in death; the shouts which they heard were shouts of exe-

cration, and their crown was the martyr's crown of thorns. We have, happily, fallen on better days; the secrets which we win from Nature we may proclaim without fear, and in the confident assurance that, after being proved and tried, they will be accepted; we are fighting a winning fight, and the stars in their courses are with us. What cause, then, for arrogant self-assertion, overbearing aggression, and willful determination to seek occasions of offense? The advantages of our position and strength entail the responsibility of moderation and forbearance, for the strength is not our own—it is the power of the universe working in us to its higher ends.

One may esteem science duly, then, without feeling sympathy with the aggressive delight with which some persons accentuate its hostility to expiring doctrines, and exult in the overthrow of articles of faith which have sustained and solaced multitudes of men in the dark hours of life and in the darker hour of death. It can be no pleasure to a generous nature, inevitable though it be, to shatter the faith of even the poor Indian, who, driven from his hunting-grounds by the inexorable fate of a stronger race, looks upward with feeble faith to a Great Spirit, and forward with dim hope to the happy hunting-grounds far away where the sun goes down. To aspire to be the first to proclaim the downfall of a position of refuge to which men have clung with passionate earnestness for many generations seems to show "a pitiful ambition in the fool who uses it," a singular blindness to the essential continuity of development, a strange ignorance of what is the final end of all science. A scientific discovery is a very good thing in its way, but it is only a means to an end, after all—the improvement of man's estate—that is to say, his moral and intellectual as well as his material state; and when he who has been happy enough to discover a new metal or a new star or a new cell or a new salt magnifies himself mightily, and fondly dreams of an immortal fame, one cannot help some such feeling of the ludicrous as would be raised by the spectacle of a hodman who, having carried his brick to the building in course of construction, should call upon all the world to take notice of the wonderful work which he had done in architecture. Science has yet to realize, at any rate its cultivators seem oftentimes to forget, that its end must be constructive; that after analysis must come synthesis; that all the analytical work in the world will leave matters in a chaotic state until the constructive spirit, moving over their surface, shall organize the incoherent results, and make them serve for a higher social development. The problem is to make straight in the future a highway over which mankind may pass to a higher life. The philosopher who, with far-reaching eye, overlooks the relations of sciences; the poet who reveals subtilties of human feeling, gives lofty utterance to human sympathies with Nature, and infuses nobler aspirations into men; the preacher of human brotherhood who, inspired with strong moral feeling, proclaims the lessons of self-

renunciation and of duty to neighbor—these are brighter stars in the firmament of human genius than the scientific discoverer. The discovery of the law of gravitation is the grandest attainment of scientific thought; but can we justly compare the effects of that generalization upon human interests and happiness with the elevating influence which is exerted by the poetry of Isaiah or of Shakespeare upon multitudes throughout the world; which is perhaps being felt at this very moment by fireside or on sick-bed in distant lands—by the solitary dweller on the skirts of the vast forests of Western America, in the great lone land of Canada, in the farthest depths of the Australian bush? Science has not rendered the philosopher, the poet, and the moral teacher superfluous, nor will it ever supersede them; on the contrary, it will have need of them to attain to its own perfect working to the bettering of man's estate; and it may well seem to some that the time has come when its manifold scattered and somewhat anarchical results should be penetrated by the synthetic insight of the philosopher, be embodied in forms of beauty by the poet's imagination, and utilized by the moral teacher to guide and promote the progress of mankind. So long as man sees splendor in the starry heavens, beauty in the aspects of Nature, grandeur and glory in self-sacrifice, so long will he feel that his brief conscious life is but a momentary wavelet on the vast ocean of the unconscious; that there is in him the yearning of something deeper than knowledge, which "cometh from afar," and which the labored acquisitions of science will ever fail to satisfy.

ABOUT SHARKS.

SHARKS are usually spoken of as the most rapacious and abhorrent of sea-animals. That they are rapacious is undeniable, but why they are so is not generally considered. We will go a little into the matter. The shark, a fish of the family *Squalidæ*, when quite in his infant state, and only a few inches in length, exhibits a pugnacity almost without parallel for his age. He will attack fish two or three times larger than himself; or, if caught, and placed for observation on the deck of a vessel, he resents handling, and, with unerring precision, strikes a finger placed on almost any part of his body.

Two things contribute to the shark's determinate fierceness. In the first place, we may refer to his teeth, for of these engines of destruction Nature has been to him particularly bountiful; and this species of bounty he has a peculiar pleasure in exercising. If he could speak, he would probably tell us that, besides being troubled with his teeth, which he could not help keeping in use, he had been gifted with enormous abdominal viscera, and that, more particularly,

a third of his body is occupied by spleen and liver. The bile and other digestive juices which are secreted from such an immense apparatus, and poured continually into the stomach, tend to stimulate appetite prodigiously—and what hungry animal with good teeth was ever tender-hearted? In truth, a shark's appetite can never be appeased; for, in addition to this bilious diathesis, he is not a careful masticator, but, hastily bolting his food, produces thereby not only the moroseness of indigestion, but a whole host of parasites, which goad as well as irritate the intestines to that degree that the poor squalus is sometimes quite beside himself for the torment, and rushes, like a blind Polyphemus, through the waves in search of anything to cram down his maw that may allay such urgent distress. He does not seek to be cruel, but is cruelly famished. "It is not I," expostulates the man in the crowd, "that is pushing; it is others behind me." The poor wretch must satisfy, not only his own ravenous appetite, but the constant demand of these internal parasites, either with dead or living food; and therefore it is that, sped as from a catapult, he pounces on a quarry, and sometimes gorges himself beyond what he is able to contain.

Having said thus much of the rapacious habits of the *Squalidæ*, we would have it remembered that every man's hand is against them, and that no tortures are considered too severe to inflict upon them when caught. If they are relentless to man and every living thing around them, their insatiable appetite renders them equally destructive to their own species, and we of the white population of this globe ought to recollect, with some show of gratitude, that they always prefer an African to a European; for, although they are fond of men of any color, a negro is to them as the choicest venison. Commerson tells us that one of the atrocious amusements practised on board slave-ships was to suspend a dead negro from the bowsprit, in order to watch the efforts of the sharks to reach him, and this they would sometimes effect at a height of more than twenty feet above the level of the sea. Wonderful are the tales that sailors tell of the various things that have been found in a shark's stomach, and it was thought that any substance that would enter its mouth was at all times acceptable. The following, which details a cruel trick, as described in the *Glasgow Observer*, dispels this illusion: "Looking over the bulwarks of the schooner," writes a correspondent to this journal, "I saw one of these watchful monsters winding lazily backward and forward like a long meteor; sometimes rising till his nose disturbed the surface, and a gushing sound like a deep breath rose through the breakers; at others, resting motionless on the water, as if listening to our voices, and thirsting for our blood. As we were watching the motions of this monster, Bruce (a little lively negro, and my cook) suggested the possibility of destroying it. This was briefly to heat a fire-brick in the stove, wrap it up hastily in some old

greasy cloths, as a sort of disguise, and then to heave it overboard. This was the work of a few minutes; and the effect was triumphant. The monster followed after the hissing prey. We saw it dart at the brick like a flash of lightning, and gorge it instanter. The shark rose to the surface almost immediately, and his uneasy motions soon betrayed the success of the manœuvre. His agonies became terrible; the waters appeared as if disturbed by a violent squall, and the spray was driven over the taffrail where we stood, while the gleaming body of the fish repeatedly burst through the dark waves, as if writhing with fierce and terrible convulsions. Sometimes we thought we heard a shrill, bellowing cry, as if indicative of anguish and rage, rising through the gurgling waters. His fury, however, was soon exhausted; in a short time the sounds broke away into distance, and the agitation of the sea subsided. The shark had given himself up to the tides, as unable to struggle against the approach of death, and they were carrying his body unresistingly to the beach."

Crouch, in his "Fishes of the British Islands," would indirectly claim some apology for the habits of the shark tribe; in reference to which he asks why the lion and the eagle should occupy the elevated places they do in popular estimation, as the king of beasts and monarch of the air. They live by the exercise of powers similar to those of the sharks, and if insatiable appetites are to take precedence, sharks ought to stand in the foremost rank.

The appearance of sharks occasionally upon our coast naturally creates a certain panic among bathers; and we may trace the breakage of the nets of our fishermen to their presence, among other causes. The six-gilled shark, or gray shark, is sometimes eleven or twelve feet in length, and is very destructive among the pilchards on the Cornish coast. The white shark is a formidable fellow; but although his class occasionally send over to our isles deputations of one or two, we have, fortunately, not had to record of late years such a visitation as that of 1785, when hundreds appeared in the British Channel. This individual is, perhaps, the most formidable of all the inhabitants of the ocean. Ruysch says that the whole body of a man, and even a man in armor, has been found in the body of a white shark. Captain King, in his "Survey of Australia," says he caught one which could have swallowed a man with the greatest ease. Blumenbach says a whole horse has been found in it; and Captain Basil Hall reports the taking of one, in which, besides other things, he found the whole skin of a buffalo, which a short time before had been thrown overboard from his ship. The blue shark is a horrible nuisance to the fishermen, but, fortunately, it is with us only in summer, when it makes itself known by hunting after the fish entangled in the nets, which it does by seizing both fish and net with its keen and serrated teeth, and swallowing fish and mesh together. As it is not always pleasant to have sharks following a ship, it cannot be too well

known that a bucket or two of bilge-water has been known to drive them off.

The shark tribe are remarkably retentive of life, and instances are related which would be almost beyond belief, if not vouched for by numbers of witnesses. For instance, an individual was caught with a line; its liver was cut out, and the bowels left hanging from the body, in which state the sailors, as an object of abhorrence, threw it into the sea. But it continued near the boat; and not long afterward it pursued and attempted to devour a mackerel that had escaped from the net. In another instance, a shark was thrown overboard after the head had been severed from the body; after which, for a couple of hours, the body continued to use the efforts of swimming in various directions—to employ the conjecture of a boy among the crew—as if it were looking for its head. Next, we have the thrasher, which has obtained the name of fox-shark, because of the shape of its tail. The title of thrasher, however, is most appropriate, from its habit of lashing the sea with its tail, by which it has been known to put to flight a herd of sportive dolphins, and even to fill the whale with terror. The porbeagle is another of the shark tribe, and is a common visitor on the western coasts in summer. Then follows that too plentiful and rapacious fish, the toper, known likewise as the white-hound, penny-dog, or miller-dog. However, as it swims deep, it does not do so much injury to the fishermen's nets as some of its congeners. Then we have the smooth-hound, or ray-mouthed dog, or skate-toothed shark, which are presumed to come from considerable distances, from the kind of hooks sometimes found in them, which resemble those used on the coast of Spain. They feed upon crustaceous animals, but will take a bait. The picked-dog, spur-dog, or bone-dog, but commonly known as the dog-fish, is the smallest, but unquestionably the most numerous of the shark tribe. It frequents our coasts all the year round, and even in the severest weather. Then there are the spinous shark, and Greenland shark, which will not be driven away from feeding upon the blubber of a stranded, half-immersed whale, although pierced with spears, but come again to the oleaginous banquet while a spark of life exists. The basking-shark also, occasionally, casts up on our coasts. It is of a large size, is capable of breaking a six-inch hawser, and is only taken with considerable difficulty. Then we have the rashleigh shark, the broad-headed gazer, and the hammer-head or balance-fish, which may be said to complete the list of these occasional unwelcome visitors to our shores.

And now that we have said so much that is prejudicial to the *Squalidæ* or shark community, let us see what we have as a set-off in their favor. As a food for man, the toper is found exposed for sale in the markets at Rome; and in Paris, that city of gastronomy, the small kinds of shark, when divested of their tantalizing titles, are to be detected as *entrées* in the *menu* of many of the most distinguished

families. For some years, the dog-fish has afforded lucrative employment during the whole of the summer to the fishermen from the Naze to the Cape. It is, however, mostly smoked, and in this way is considered rather a delicacy. It is also dried and split as stock-fish for consumption in the country, as well as for export to Sweden, where it is greatly appreciated. It is likewise elsewhere a common article of food, amid the choice of a variety of other fish, especially in the west of England, and, indeed, is valued by some who are far above the necessity of classing it with their ordinary articles of subsistence. It is used both fresh and salted, but, when eaten fresh, it is skinned before being cooked. Lacipede, who speaks slightingly of its flesh, informs us that, in the north of Europe, the eggs, which are about the size of a small orange, and consist solely of a pale-colored yolk, are in high esteem. If prejudice could be got over, there is no doubt they would form an agreeable as well as a nourishing article of food, as a substitute for other eggs in our domestic economy.

The shark-fishery is carried on in many parts of the Indian Ocean, and on the eastern coast of Africa, and recently it has been pursued on the coast of Norway. About Kurrachee, in India, as many as 40,000 sharks are taken in the year. The back-fins are much esteemed as a food delicacy in China, from 7,000 to 10,000 of these being shipped to that empire annually from Bombay. In Norway and Iceland the inhabitants make indiscriminate use of every species captured, hanging up the carcasses for a whole year, like hams, that the flesh may become mellow. The liver, however, appears to be strictly prohibited everywhere, as a dangerous article of food.

Mr. N. Brabazon, in his "Fisheries of Ireland," in allusion to the large shoals of sharks which pass annually along the west coast, on their way from the southern to the northern seas, speaks particularly of the basking shark: "These fish are worth from £35 to £50 each; and when so many as five hundred have been killed in one season, this class of fishing should be well attended to for the short season it lasts, if the weather is favorable to it, especially as it is at a time when other fish are out of season. The fishermen have a superstition that the fish will leave the coast if the bodies of those caught were brought to the shore." Mr. P. L. Simmons, in his "Waste Products and Undeveloped Substances," gives almost incredible statistics of the vast amount of fish-refuse which is either left to rot on the coasts and putrefy the air, or thrown back into the sea unutilized, both on our own and on foreign shores; and he significantly points to its value as a manure not far inferior to guano, of which this country alone requires 200,000 tons a year, and pays upward of £22,000,000. Would it not, therefore, be wise for enterprise and capital to begin to turn more attention to the manufacture of fish-guano, of which the *débris* of the North American fisheries, and those of the North Sea, would furnish ample material?—*Chambers's Journal.*

ABORIGINAL SETTLEMENTS OF THE PACIFIC COAST.

By PAUL SCHUMACHER.

IF we investigate the condition of the ground upon which we now find the ruined settlements of a former people on this coast, it cannot fail to convince us either that all such stations had been established on sandy ground, or that the ground had been artificially changed by sand carried thither when it was rocky or hard. Sandy soil was a necessity, that they might employ their rude and imperfect tools in the erection of houses partially dug in the ground and surrounded by embankments. It was also a requirement for cleanliness and health, owing to its absorption of moisture in the rainy season. Overgrown or firm sandy ground was preferable to bare, loose sand; but even the drifting dunes offered them a better choice than the dark humus intermixed with rock. Other requirements of a well-located *ranchería* were: proximity of potable water, a commanding view, the outlying

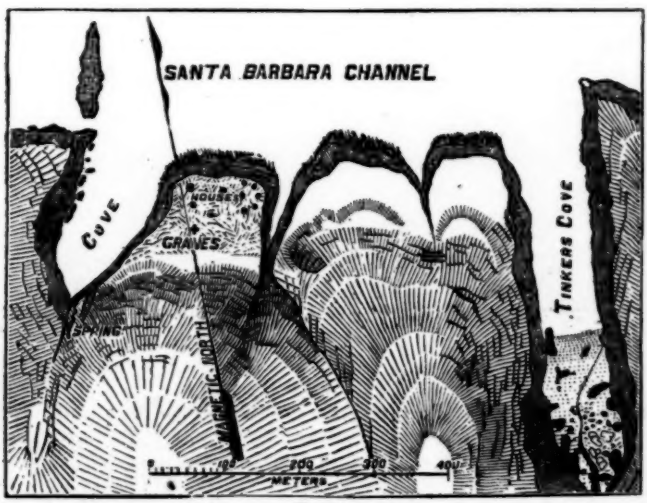


FIG. 1.

rocks bearing eatable mollusks, fish in the adjoining kelpy waters, and game in the neighboring country. Water in small rivulets and springs was preferable to larger streams and rivers, unless these were stocked with fish. A commanding view was subordinate to the condition of the soil and the proximity of water, especially on the islands in Santa Barbara Channel, where no surprising enemy was to be guarded against; there a small boat-landing was one of the main considerations, because the islander's sustenance was mainly derived from

fishing, hunting on the water, and barter with the dwellers on the mainland. To gather shell-fish the aborigines often went long distances, which called into existence temporary camps wherein we hardly find anything but layers of shells and some burned beach-rocks, indicating former fireplaces, scattered in small clusters over their surface. The mollusks, after their shells had been removed, were dried in such temporary camps for easier transportation to distant villages.

But let us examine one of the sites of such aboriginal villages, commonly termed "shell-heaps" or "shell-mounds," bleached shells being by far the larger and more conspicuous part of their remains. I will select one of the many stations which I have investigated for the Smithsonian Institution during recent years. Its location is near a narrow inlet, called Tinker's Cove, on the island of Santa Cruz, one of the group in the Santa Barbara Channel (*see* Fig. 1). It possesses all the requirements of an aboriginal settlement, only the game-ground

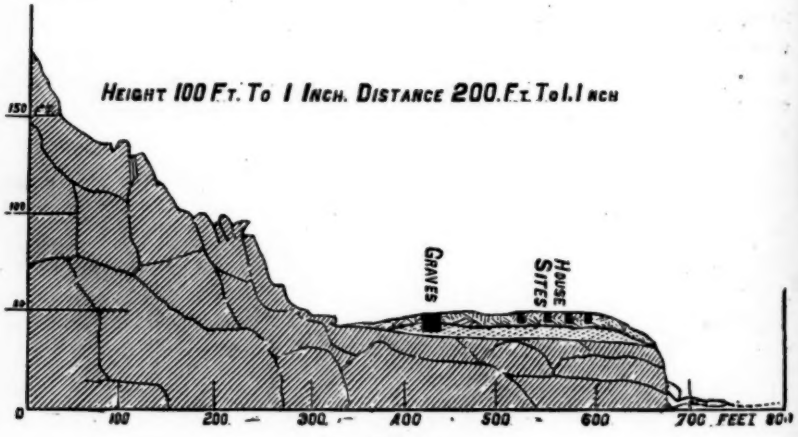


FIG. 2.

is wanting, as no animals save a small gray fox, and several species of land-birds, exist on the islands. The ground upon which the station is located is of a rocky, irregular structure, mostly bare and destitute of vegetation; a cove, affording an excellent boat-landing, adjoins to the westward of it; outlying rocks, of which but few appear in the sketch, are covered with edible shell-fish; a mass of kelp and sea-weed grows in the adjoining waters, and is thickly stocked with fish; a spring of potable water is found in the deepest part of the cove. Sand is found only at a distance of between four and five hundred yards to the eastward, in a small hidden beach of the narrow fiord of Tinker's Cove, which is of very difficult access by land, as the sides of the inlet form walls of over one hundred feet in height, and in larger quantities farther away to the westward of the station. It is,

therefore, evident that the layer of sand covering its rocky ground is artificial, and placed there by the aborigines, not a natural deposit accumulated by drifts, etc. The mound begins at the brink of the bluff, some thirty feet above high-water mark, and extends back over a flat of a little more than one hundred yards, toward the ascending hill, diminishing gradually in height, and ceasing entirely before the rocky outcroppings are reached, whence the ground rises rapidly into a ridge, forming a spur of the backbone of the island (*see* Fig. 2). Investigation revealed the artificial formation to consist of a layer of shells, most of which are still found among the living species on the island, bones of fish, sea-fowl, seal, and sea-lions, and whales, dogs and foxes, and a great mass of cobble-stones of all sizes, especially of the size of a fist as used for fireplaces, and chippings of different varieties of chert, chalcedony, jasper, quartz, etc.—rocks suitable for the manufacture of knives, arrow-heads, spear-points, and other cutting tools, which do not occur *in situ* on the island and had to be imported. The whole is mixed with a large quantity of sand, reaching to a depth of about five feet at its deepest part, where formerly the dwellings stood. Underneath the layer of animal remains, the kjökken möddings—kitchen-middens or cooking *débris*—of a former people, pure sand is met in which we find but few valves of an edible shell-fish, or beach-rocks showing marks of fire, or such marks as are made by human hands, and were probably introduced while the dwelling-mound was raised pre-

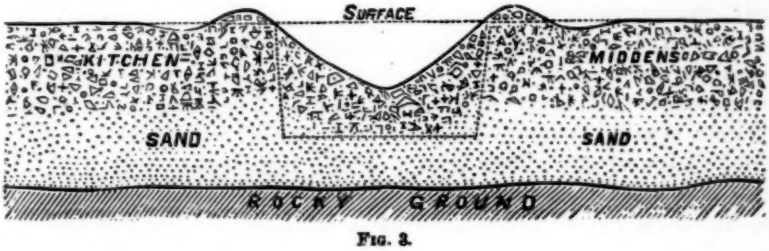


FIG. 3.

paratory to the erection of the hut. The sand—which was either carried there overland, or in canoes from some neighboring sand-bank—attains a depth of about three to four feet, and is deepest around the circular depressions of the house-sites, indicating the embankments which had been raised around the huts. The section, Fig. 3, represents a site of a former dwelling as now found, and its original depth, as indicated by broken lines, may occasionally be traced by still remaining upright boards of the former subterranean inclosure. After the erection of the dwellings, the accumulation of the kjökken möddings began to spread all over the town-site, but was kept imbedded in sand by fresh supplies, thus raising the level of the village gradually, and increasing the depth of the subterranean part of the hut until the latter was deserted, or built over with a new structure.

Near the houses, where in all probability the cooking *débris* had first been deposited, it is now and then found in heaps almost destitute of sand; but, no doubt, after a large quantity had thus been accumulated, it was spread over the ground of the town, evened, and smoothed by layers of sand. The proportion of sand mixed with the cooking *débris* is about one-half the weight of the whole mass. The size of a town-site varies from about 100 metres in length and width, like the one illustrated in the figure, to 1,200 metres, or three-quarters of a mile, in length, and from 100 to 300 metres in width, the extent of *Os-bi*, a *rancheria* in Santa Barbara County, about five miles south of Point Sal, which is the largest shell-mound derived from permanent habitation thus far explored on this coast.

The same features of an aboriginal settlement we observe in Oregon, 1,000 miles to the north. If we take, for instance, the ruined settlement of the *Chetl-e-shin*, situated on the commanding elevation of the north bank, and near the mouth of Pistol River: in front the wide ocean expands, with a number of large outlying rocks; Pistol River washes the base of the bluff upon which the station is situated; its waters are stocked with trout, and, in certain seasons, abundantly with salmon; to the left, or eastward, a mountain-brook empties into the river at the foot of the *rancheria*, and a spring issues between the upper and lower town-sites; back of the coast the country extends in a gradual rise toward a steep and heavily-timbered ridge, beyond which it becomes almost impenetrable, owing to thick forests and their undergrowth, and vines, the safe home of elk and bear. The rocky ground upon which the town was located is covered with a deposit of sand, of which the neighboring beach offers an abundance, and kjökken möddings of great age in its lower layers, with that peculiar mouldy, ash-like appearance, sprinkled with particles of decayed shells, so characteristic of an aboriginal settlement.

It is evident that such a ground, needing artificial foundation for the establishment of a town, was not suitable either for a burying-ground site; we must, therefore, look for the graves of these people within the artificial mounds. There is an exception to this when the ground is naturally sandy, or soft; then we must look for the graves within an easy distance, say about 150 metres, in some prominent place and in sight of the *rancheria*. The graves consist of a pit varying between two and fifteen metres square, and not over two metres in depth, partitioned into smaller spaces by whales' bones and slabs of stone, or by wood. On the islands the gigantic bones of the whale are almost exclusively used; while, on the neighboring mainland, limestone, which splits board-like into slabs, and also whales' bones, and pine and red-wood, are used. Graves of this description have been found in California south of San Francisco, while in Oregon the mode of burial is different, the interment being either made in detached graves, or in houses previously demolished by fire.

SKETCH OF SIR WILLIAM THOMSON.

THIS distinguished physicist and mathematician was born in Belfast, in June, 1824. His father, Dr. James Thomson, was a man of large capacity and culture, who studied in the Glasgow University, became head-master of the Belfast Academical Institution, and in 1832 was appointed Professor of Mathematics in the University of Glasgow. He made various improvements in mathematics, and wrote books upon education. William passed through the Glasgow University early, and then entered St. Peter's College, Cambridge, from which he graduated as second wrangler in 1845, and he was immediately elected Fellow of his college. He afterward went to Paris, and worked in the laboratory of Regnault. In 1846, at the early age of twenty-two, he was appointed Professor of Natural Philosophy in the University of Glasgow, a position which he has filled with distinction, and still occupies.

Sir William Thomson's earliest contributions to physical science were on the subject of heat, the laws of its motions being treated mathematically. A remarkable paper on "The Uniform Motion of Heat in Homogeneous Solid Bodies," written at the age of seventeen, was full of original conceptions, but it was afterward found that Thomson had been anticipated in his ideas by Gauss, Chasles, and George Green, of Nottingham. In 1842 he published an important paper on "The Linear Motion of Heat," which contained a method of deriving geological dates from underground temperatures, a subject which he treated in his inaugural address, in entering upon his professorship at the university.

It will be impossible here to give any account of the numerous contributions to science made by Sir William Thomson, as they were generally of so mathematical a cast as to be unintelligible to ordinary readers. His papers on "Electro-Statics" and on "Magnetism" were collected and published in 1872, in a valuable volume of six hundred pages. The more interesting aspects of his work have been well described by a writer in *Nature*, and we cannot do better than to quote some passages from his notice:

"His electrostatic researches led Thomson to the invention of very beautiful instruments for electrostatic measurement. The subject of electrostatic measurement occupied much of his attention from the very earliest, when he was obliged to call attention to the defects of the electrometers of Snow Harris. His labors in this direction have produced the quadrant electrometer, which is employed for all kinds of electric testing in telegraph construction, and for the registration of atmospheric electricity at Kew Observatory; the portable electrometer, for atmospheric electricity and for other purposes, in which the extreme sensitiveness of the quadrant-electrometer is not required; and the *abso-*

lute electrometer, which serves for reducing the scale-readings of other instruments to absolute measure, and which was used by Thomson in his measurement of the electrostatic force producible by a Daniell's battery and in many other investigations. Those who have seen the collection of electrometers in the Loan Collection at South Kensington will not think it too much to say that to Sir W. Thomson is due our present system of practical electrometry.

"But while thus engaged in investigations in electrostatics and magnetism, there were many other branches of science that were receiving from him advancement in a not less remarkable way. There is no part of his work of higher importance than his investigations on the Dynamical Theory of Heat. These were communicated in a series of papers to the Royal Society of Edinburgh, the first of which was given in 1849. It was a critical account of Carnot's memoir of 1824, 'Réflexions sur la Puissance Motrice du Feu.' Though Rumford and Davy had, in the beginning of this century, experimentally disproved the material theory of heat, their experiments and arguments were unheeded and nearly unknown; and it was only after 1843, when Joule actually determined the dynamical equivalent of heat, that the great truth that heat is a mode of motion was admitted and appreciated. Thus Carnot, although dissatisfied with it, was obliged to adopt the material theory of heat in 1824; and, regarding heat as indestructible, spoke of the letting down of the heat from a higher to a lower temperature, and looked on the production of work by the heat-engine as a phenomenon analogous to that in which water, descending from a higher to a lower level, does work by means of a water-wheel. Thomson, among the first to appreciate the importance of Joule's results, set himself to alter the theory given by Carnot into agreement with the true theory; and in the series of papers referred to, placed the whole science of thermodynamics on a thoroughly scientific basis. In 1846 he first suggested the reckoning of temperature on an absolute thermodynamic scale independent of the properties of any particular substance. Subsequently, in consequence of experimental investigations of the thermodynamic properties of air, and other gases, made in conjunction with Joule, he showed how to define a thermodynamic scale of temperature having the convenient property that air-thermometers and other gas-thermometers agree with it as closely as they agree with one another. This system of reckoning temperature gives great facility for the simple expression of thermodynamic principles and results.

"Having here mentioned Joule and Thomson together, we cannot omit to remark that some of the most admirable researches in thermodynamics were those undertaken in conjunction by these two attached friends.

"Among the many important results of Sir W. Thomson's investigations in thermodynamics, one of the most remarkable was his discovery of the principle of dissipation of energy, announced by him in 1852. During any transformation of energy of one form into energy of another form there is always a certain amount of energy rendered unavailable for further useful application. No known process in Nature is exactly reversible, that is to say, there is no known process by which we can convert a given amount of energy of one form into energy of another form, and then, reversing the process, reconvert the energy of the second form thus obtained into the *original quantity* of energy of the first form. In fact, during any transformation of energy from one form into another, there is always a certain portion of the energy changed into heat in the process of conversion; and the heat thus produced becomes dissipated and diffused by radiation and conduction.

"Consequently, there is a tendency in Nature for all the energy in the universe, of whatever kind it be, gradually to assume the form of heat, and, having done so, to become equally diffused. Now, were all the energy of the universe converted into uniformly-diffused heat, it would cease to be available for producing mechanical effect, since for that purpose we must have a hot *source* and a cooler *condenser*. This gradual degradation of energy is perpetually going on; and sooner or later, unless there be some restorative power, of which we at present have no knowledge whatever, the present state of things must come to an end.

"In 1854 Faraday, with an experimental cable, investigated the cause of the *retardation of signals* first observed in the working of the cable between Harwich and the Hague. Thomson, taking up the question, published an investigation of the nature of the phenomenon, one practical result of which was that with cables similar in lateral dimensions the retardations are proportional to the *squares of the lengths*. This law is now commonly referred to as the 'law of squares.' About this time it was proposed to construct a cable to connect England with America; and it became obvious that the discovery of the retardation of signals raised a question whether the transatlantic cable would not prove a commercial failure. Whitehouse, experimenting with 1,125 miles of cable, found the transmission of an instantaneous signal to the farther end of the cable to occupy one second and a half. The length of a cable required to connect Ireland with Newfoundland is twice that of the experimental cable of Whitehouse; and thus, according to the law of squares, the time taken to transmit an instantaneous signal through a cable similar in lateral dimensions to that of Whitehouse, and joining those two places, would be no less than *six seconds*. In 1856 Whitehouse read a paper before the British Association, in which he described experiments by which he hoped to disprove the law of squares. Thomson replied in the *Athenæum* (November 1, 1856); and subsequent experiments have established the correctness of his law.

"Fortunately a true understanding of the nature of the phenomenon of retardation led Prof. Thomson to the method of overcoming the difficulties presented. The disturbance produced at the extremity of a long submarine cable by the application for an instant of electromotive force at the other end is not, as in the case of a signal through an overhead land-line, a pulse, practically infinitely short, and received only a minute fraction of a second after it was communicated. Instead of this, a long wave is observed at the farther extremity, gradually swelling in intensity, and as gradually dying away. Its duration for such a cable as we have been speaking of would be the whole six seconds, calculated from the experiments of Whitehouse. Prof. Thomson perceived that an instrument was required which should give an indication of a signal received long before the wave has acquired its maximum intensity, and in which the subsequent rising to maximum intensity should not render unreadable a fresh signal sent quickly after the previous one. This was effected by his 'mirror galvanometer;' and it was by means of it that the messages transmitted through the 1858 Atlantic cable were read.

"The 1858 cable, submerged under difficulties that many times threatened to be insurmountable, soon failed. Several important messages were, however, transmitted through it; and it served to *prove* the feasibility of the project which many eminent engineers up till that time regarded as chimerical. Before another attempt was made the labors of Prof. Thomson and others, to all of whom the world owes a deep debt of gratitude, had so improved the construc-

tion of the cables and the mechanical arrangements for submersion, that though many difficulties presented themselves they were all, in 1866, triumphantly overcome. It was on his return from the submersion of the 1866 cable, and the raising and the completion of the 1865 cable, that the honor of knighthood was conferred on him along with others of his distinguished fellow-workers.

"Recently Sir William Thomson has invented a new and very beautiful instrument, the 'siphon recorder,' for recording signals on long submarine lines. It is in use at all the telegraph-stations along the submarine line connecting England with India. It is also used on the French Atlantic Cable, and on the direct United States line. Sir W. Thomson, Mr. Varley, and Prof. Jenkin, combining their inventions together, have given the only system by which submarine telegraphy on long lines has been carried on up to the present time.

"Sir William Thomson is an enthusiastic yachtsman and a skillful navigator. His recently-published popular lecture on 'Navigation' proves this; and, with that bright genius which enriches all with which it comes in contact, his improvements in navigation are of very high importance. The general adoption of Sumner's method, now made simple for the navigator, would be a reform in navigation almost amounting to a revolution, and is one most highly to be desired. Sir William Thomson has also invented a new form of mariner's compass of exquisite construction. It possesses many advantages over the best of those in general use, not excluding the Standard Admiralty Compass; but its special feature is that it permits of the *practical* application of Sir George Airy's method of correcting compasses for the permanent and temporary magnetism of iron ships. He has also invented an apparatus for deep-sea sounding by piano-forte wire. This apparatus is so simple and easily managed that he has brought up 'bottom' from a depth of nearly three nautical miles, sounding from his own yacht, without aid of steam or any of the ordinary requisites for such depths. His method was much employed in taking rapid soundings during the laying of telegraph-cables along the Brazilian coast to the West Indies. It has also been used with great success on the United States Submarine Survey. Recently, while on his way to Philadelphia, Sir W. Thomson himself was able to take flying soundings, reaching the bottom in sixty-eight fathoms, from a Cunard Line steamship going at full speed.

"Sir William Thomson is a Fellow of the Royal Society of London and of the Royal Society of Edinburgh. He has received the Royal Medal of the former and the Keith Medal of the latter. He is also an honorary member of several foreign societies. The Universities of Dublin, of Cambridge, and of Edinburgh, have each conferred upon him the honorary degree of LL. D., and that of Oxford the honorary degree of D. C. L. On his marriage in 1852 he gave up his fellowship at St. Peter's College, Cambridge; but in 1871 his college again elected him to a fellowship, which he now holds."

CORRESPONDENCE.

INSECTS AND FLOWERS IN COLORADO.

To the Editor of the Popular Science Monthly.

IN my paper on "The Fertilization of Flowers by Insect Agency" ("Proceedings of the American Association for the Advancement of Science," 1875, pp. 244, 245), I say: "On my first visit to the Rocky Mountain region, the absence of insects proved very annoying to the entomologists who accompanied me. Indeed, the paucity of animal life of all kinds in the Rocky Mountains is well known; but there is no more scarcity of seed in the colored flowering plants than in similar ones elsewhere." At the conclusion of my address, Prof. Riley objected to the accuracy of this statement—not from his own personal experience, as I believe, and from overlooking, as I supposed, that I was referring to insects relating to the cross-fertilization of flowers—chiefly *Hymenoptera* and *Lepidoptera*. Mr. Charles R. Dodge, editor of *Field and Forest*, was one of the entomologists I referred to. In vol. i., No. 12, page 89, he describes that expedition in the summer of 1871: "The route carried us through Golden City and Idaho Springs to South Park, thence to Pike's Peak and the Garden of the Gods, where we emerged from the mountains and returned to Denver over the level plateau known as the 'Divide;' and, from the time we passed the foot-hills near Golden City, and entered the first cañon in the mountains, we were struck with the comparative paucity of the insect fauna. . . . In the mountains, the marked *absence* of insect-life in variety, except in favorable localities, was the rule, and not the exception." Traveling was not so easy then as now, and I think it took us nearly three weeks. The party comprised thirty persons, all of whom were interested in aiding the collectors. Mr. Dodge sums up his remarks by especially noting that "the entire mountain-trip yielded so small a number of nocturnal *Lepidoptera* that they are hardly worth mentioning." He adds, "I have conversed with a few other entomologists on this subject, and they agree with me perfectly."

Now, if we turn to Hayden's "Report of the Survey of Colorado," for 1873, we find Lieutenant Carpenter substantially recording the same thing. Here are the doings of a whole season, and not for three weeks merely, and only five species of butterflies are found; and, indeed, he remarks that "*Lepidoptera* are undoubtedly peculiar to high latitudes and great elevations." This leaves us with scarcely anything but bees to do the whole work of flower-fertilization in the Rocky Mountain region. But even these seem to be confined to some considerable elevation. In an expedition in 1873 I saw *Bombus termarius* in abundance, but on no other flowers than *Polygonum bistorta*, on Gray's Peak, on the flats near the timber-line. I was struck by the fact that they seemed to visit only this species, evidently getting all they required from it, and neglecting everything else. I did not see bees anywhere in our expedition of 1871 in lower altitudes, nor do I think there were any in 1873, except in this high region near the timber-line. Of course, there might have been, but, if so, they were so scarce as to attract little attention. This seems to have been the experience of Lieutenant Carpenter. He says, "The humble-bee was always to be seen in midsummer at the verge of the Alpine flora, busily engaged in collecting its store of pollen from the few flowers to be found." This does not certainly say they might not be found lower down, but it is a fair inference. My collections in this district embraced over seven hundred species of flowering plants and ferns. I can say that among these were quite as large a proportion of colored flowers as in an equal number gathered East, where insects are conceded to be numerous.

But just here Prof. Gray steps in with the following note: "*À propos* to Mr. Meehan's suggestion that, although the Alpine plants of the Colorado Rocky Mountains are mostly high colored, insects are there so rare that they can be of no material aid to fertilization, and therefore these plants

must self-fertilize, it may not be amiss to introduce testimony. An entomologist now at my side, who has passed four summers among these mountains, and made frequent visits to the Alpine regions, informs me that 'he has always found insects of all orders quite abundant in the Rocky Mountains'" (*Silliman's Journal*, 1876, pp. 397, 398). The route which I have described can hardly be called the "Alpine" region, unless it be in so far as it relates to Pike's Peak, which, however, I did not join my companions in ascending, having chosen in preference to explore alone what was then an unknown cañon, and which I named after my good friend Dr. Engelmann, whose name it still bears. There is nothing in my paper, as referred to by Prof. Asa Gray, to warrant the statement that I was confining myself to "Alpine" regions. Indeed, the "suggestion," so far as it relates to the paucity of insects, should refer to the "entomologists who accompanied me," and not to myself. All I claim is that the "entomologists" found no insects, while I found colored flowers seeding abundantly.

In view of the testimony of the entomologist at Dr. Asa Gray's side, that insects of all orders are quite abundant in the Rocky Mountains, I should be glad to have, through THE POPULAR SCIENCE MONTHLY, a list of the *Hymenoptera* and *Lepidoptera* that are abundant enough, in the particular part of the Rocky Mountain region covered by my experience, to probably act as cross-fertilizers of flowers, noting those which may perhaps be introduced since 1871, as it is well known that, with the introduction of agriculture and horticulture, insects often follow.

I do not suppose that, in the large number of observations I have placed on record, there will not be now and then one found "imperfect." Not one of us who are working in this field but, with all our care, must expect such annoyances. As the relation of insects to plants in the flora of Colorado is an important one, and I never heard the view I have taken of it questioned except as now stated, I think it important to science to know exactly how far my statement is imperfect, if imperfect at all.

THOMAS MEEHAN.

GERMANTOWN, PA., *November* 27, 1876.

THOMAS CARLYLE AND THE DARWINS.

To the Editor of the Popular Science Monthly.

THERE are floating in the American press some ill-natured remarks of the octogenarian, Carlyle, that merit a little attention. The remarks reported are as follows: "I have known three generations of the Darwins—grandfather, father, and son: atheists all. . . . I saw the naturalist not many months ago; I told him that I had read his 'Origin of Species' and other books; that he had by no means satisfied me that men were descended from monkeys, but had gone far toward persuading me that he and his so-called scientific brethren had brought the present generation of Englishmen very near to monkeys. A good sort of a man is this Darwin, and well-meaning, but with very little intellect."

REMARK 1. If a "very little intellect" can change the present generation of Englishmen to monkeys, what are those Englishmen made of?

REMARK 2. Carlyle has known the three generations of the Darwins, beginning with the grandfather. Erasmus Darwin, the grandfather, died in 1802, about six or seven years after Carlyle was born! Is it exactly the right thing for the old gentleman to say he knew him?

REMARK 3. "They are atheists all." Now, two years before Mr. Carlyle was born, to wit, 1794, the grandfather, Erasmus Darwin, published the great work of his life, "The Zoönomia, or Laws of Organic Life," and on the first page he says: "The great Creator of all things has infinitely diversified the works of his hands, but has, at the same time, stamped a certain similitude on the features of Nature, that demonstrates to us that *the whole is one family of one parent.*" And, on page 77, he says expressly: "I do not wish to dispute about words, and am ready to allow . . . and to believe that the ultimate cause of all motion is immaterial, that is, God." Mr. Carlyle may be a well-meaning man, but his knowledge of that grandfather, although at the ripe age of six years, must have been rather imperfect.

But the charge of atheism includes the naturalist, Charles Darwin. The candid readers of Charles Darwin's works know better. Many people, on reading the books of Genesis and Job, grow skeptical; but no

one who reads the marvelous revelations of the works of God which this learned naturalist has published can for a moment doubt the existence of the divine wisdom which pervades the realms of Nature.

R. M. K. ORMSBY.

CHESTER HILL, N. Y., *November* 27, 1876.

To the Editor of the Popular Science Monthly.

DEAR SIR: In a letter addressed to you, and published in your columns, from the pen of Thomas Meehan, Esq., in which he is "getting right on the record," I am disturbed by the following expression in reference to my Buffalo address: "Prof. Morse could only help me with the audience by remarking, 'We all know that Mr. Meehan is a Darwinian, and an evolutionist, but must say he has an odd way of putting it.' That my good friend does not regard me as much of either is, however, clear, from his making no reference to any of my labors in his 'History of Evolution.'"

The reader of this might think that I had either overlooked the interesting contributions of Mr. Meehan in the "Proceedings" of the Philadelphia Academy, and his own journal, or else had done him a manifest injustice. That I am not guilty, either of oversight or injustice in this matter, the following lines from my Buffalo address will prove: "A review of the work accomplished by American students, bearing upon the doctrine of descent, must of necessity be brief. Even a review of a moiety of the work is beyond the limits of an address of this nature. *And for obvious reasons I must needs here restrict it to one branch of biology, namely, zoölogy.*" The *obvious reason* is that I am not a botanist, therefore no reference is made to the works of Dr. Gray, Mr. Meehan, Prof. Beal, and others, who have made valuable contributions to the subject. In the solitary case where I alluded to the fertilization of yucca, it was to show the curious moth *Pronuba*, so admirably described by Prof. Riley, as an insect showing peculiar adaptations for the work in hand. EDWARD S. MORSE.

SALEM, MASSACHUSETTS, *November* 4, 1876.

EDITOR'S TABLE.

PHILANTHROPIC FANATICISM AGAINST SCIENCE.

REFERENCE has been repeatedly made in our pages to an English Parliamentary Commission, appointed to inquire into the practice of vivisection, or experiments upon living animals, made for scientific purposes by the physiologists of that country. The inquiry was the consequence of a prolonged and intense public agitation, in which the sympathies of the people were excited, and their indignation aroused, by frightful stories of cruelty deliberately and wantonly perpetrated upon innocent animals under the pretext of advancing scientific knowledge. The movement was systematically and skillfully engineered by those who make philanthropy a business. Money was plentifully contributed by the rich to carry it on, and with plenty of money there is never any difficulty in engaging the press in a good work. Appealing to the sensibilities by exaggerated accounts of the way poor animals were tortured, the subject naturally took a deep hold of the sympathies of women, and its measures were promoted and sustained by many ladies of wealth and high social position, and were understood to be warmly encouraged by the queen herself. But the humane feelings of both sexes were profoundly stirred by the tales of atrocity that were circulated, so that the scientific physiologists of the country began to be looked upon as fiends, reveling in the infliction of agony upon helpless animals. The stories, of course, were unscrupulous exaggerations, or arrant lies, but the public is a great believer and fond of pungent sensations, while fervid philanthropy is not apt to trouble itself much about cool matters of evidence.

The Parliamentary Commission, con-

stituted of both the enemies and the friends of vivisection, at length took the matter up, and, as is customary with English commissions, it made a thorough investigation. Witnesses on both sides gave voluminous testimony on all aspects of the subject, and after patient and impartial consideration the body made a report which was designed to be preliminary to legislation upon the question. As regards the merits of the controversy, it was agreed that vivisection, or operations upon living animals, is a necessary and a proper thing, and, as practised by scientific men, has been of great use to the world. The commission, moreover, entirely acquitted the physiologists of the charge of cruelty. It commended the humanity of the medical profession in England, and testified that medical students were extremely sensitive in regard to the infliction of pain on animals.

One would think that with this decisive expression on the general subject, and with this complete vindication of the aspersed parties, the agitators would have been rebuked, and the case at once dismissed. But the anti-vivisection movement was quite too formidable to allow of this. That hysterical rampage of British philanthropy was strong enough to coerce the Government against its own protestations, and to extort from it a law that was alike an insult to science and a disgrace to the country. The physiologists were expressly acquitted of all improper practices when left free as they had always been to pursue inquiries in their own way, and they were then handed over to the future control of the police. They were vindicated from all imputation of cruelty, and then subjected to the operation of a statute against cruelty to animals. Though their experiments had for their object the ultimate mitigation of pain to the higher creatures most susceptible of pain—though their investigations were of so beneficent an influence that, as Prof. Tyndall justly says, "no greater calamity could befall the human race than the stoppage of experiments in this direction"—yet the physiologists were classed by law with those cold-blooded brutes who cruelly overdrive, abuse, and torture domestic animals. Though the necessity, and form, and extent of his experiments on animals were, in the nature of the case, matters of which the operator alone could judge, as their essential object is the elucidation of undetermined problems, yet it was legislated that he should not pursue his work except by a license from a political office-holder, and the making of any experiment calculated to give pain to an animal was declared an offense punishable in the first instance by fine, and in the second by fine and imprisonment, unless certain conditions were complied with to the satisfaction of the said political functionary who was put in control of the whole business. In short, legislative wisdom, stimulated by philanthropic zeal, outlawed vivisection as a crime, and then provided for its perpetration by leave of the Secretary of State.

Let us now see how much there was of real philanthropy or of hearty sympathy for the sufferings of the lower animals at the bottom of this movement. Had it been sincere, or based upon principle, it would have undoubtedly aimed to be effectual, and to have inflicted the penalties for cruelty alike upon all delinquents. But the law was so framed as to bear hard only upon the poor, and to give a virtual license to the rich, who could easily pay the fines prescribed for inflicting whatever cruelties they chose. Again, the law passed was intended, by the terms of its title, to prevent "cruelty to animals;" but a clause was quietly introduced at the end limiting it to the protection of *domestic* animals only—a clause which stultified the enactment, and showed the emptiness of its purpose by exposing immensely the greater portion of the inferior animate cre-

ation to all the wantonness of torture; and not only that, but to tortures that were sure to be inflicted, and were provided for by the limitations of the statute. Of the sufferings to which certain of the lower animals are subjected by the favorite English pastime of hunting them with hounds, which is freely permitted by law, we do not speak, but will only refer to some facts regarding the universal English sport of "shooting." It is well known that the British Parliament generally adjourns about the time that the partridges and grouse cease to be protected by the game-laws of the country; and no one who knows anything of the strength of British instincts for destructive field-sports will consider the connection, in this case, as altogether fortuitous. Lords, Commoners, and everybody that can afford it, then seize their guns, and betake themselves to the fields and mountains wherever there is anything to be killed. It is the fashionable and the national thing. Those who own grounds range over them with their guests in quest of beasts and birds, and others hire the privilege of doing it for longer or shorter times. The whole matter is legally regulated. Licenses are issued to keep guns, and licenses to kill game. A few of all the multitudes who enter upon the sport are good shots, and kill a large portion of the creatures fired at. But the most of them are bad shots, and wound many more than they kill. When hit, if not captured, they escape with their bodies penetrated with leaden pellets—some of them to die; some to suffer miserably; and others to recover after experiencing various degrees of pain. A writer in *Nature* has gone into the statistics of shooting, with a view to estimate the probable numbers of creatures that thus suffer by wounding. He adopts as his basis the number of those who take out licenses, the duration of the season, and the days given to sport, and, by reckoning the number wounded per day that are not killed, he arrives at a proximate conclusion regarding the aggregate of animals that yearly suffer from this cause. The number of licenses issued is taken from government reports, which indicate, for example, that in the year 1873–'74 there were 132,036 holders of gun-licenses, and 65,846 holders of licenses to kill game. Assuming that each sportsman wounds three head of game per day, which are not taken, he finds that the total number of animals upon which pain is thus inflicted amounts to many millions annually. We cannot go into the details of his calculation, which is carefully and fairly made out, but will quote the concluding passage of his article:

"If we may trust our figures, here are the plain facts that acute pain of uncertain duration was, in the year ending March 31, 1874, inflicted upon *over twenty-two million* animals, and in the following year upon *over twenty-three million and a half*, in the British Islands. We are not aware that we possess any bias that would make us exaggerate our estimates to produce these results. Our only object is to attempt as near an approximation to the truth as we can. The figures stand for themselves, and if any one thinks he can furnish fairer averages let him give his data for them. We are, as it is, willing to guard against any unconscious exaggeration, and to knock off more than ten per cent. of our grand totals, so as to say roundly that only twenty millions have suffered in each year. But we would invite our readers to reflect on the proportion which even that number bears to the number of animals which during the same time have been subjected to experiment by the physiologists of this country. The latter have been by many excellent persons held up to obloquy as monsters of cruelty. If this has been done justly, what must they think of those who use the gun?"

From the point of view here presented, the state of the case has been pithily summed up by Mr. Lowe, in a recent able article in the *Contemporary Review:*

"According to present British law, as revised under the spur of the latest philanthropy, it appears that, while the man of

science must not inflict the least pain on any animal for the most beneficent object, any one else may inflict the most exquisite tortures on any non-domestic animal—that is, on ninety-nine hundredths of the brute creation—without any punishment at all. If he can show that the torture was inflicted from cruelty, from gluttony, for money, for amusement—for any motive, in fact, except a desire to do good by extending knowledge—he enjoys the most perfect impunity; but woe to him if in his infliction of pain there is any alloy of science!"

An attempt was made to protect animals from pain against the sportsman as well as the man of science, by putting both upon the same footing as regards penalties, but it failed. Mr. Lowe says:

"A motion to extend the law which forbade the cruelly abusing or torturing any domestic animal, to animals non-domestic, and to increase the penalty to a level with the penalty imposed for performing a painful experiment, was lost by a large majority, the Government voting against it. . . . The efforts, therefore, of the two Houses of Parliament to introduce humanity into our laws, as regards animals, stands thus:

"1. Absolute liberty to torture all non-domestic animals except by way of scientific experiment.

"2. Practical liberty for any one who can afford to pay five pounds to torture domestic animals except by way of scientific experiment.

"3. No punishment for painful experiment except by leave of the Secretary of State."

Now, politicians are not partial to science, but the British Government would never have committed itself to such ridiculous legislation except for the pressure of a fanatical agitation which grew out of no real sympathy with the sufferings of the lower animals. Had it been so, the crusade would have been directed against sportsmen for their extensive and selfish infliction of cruelty, rather than against the physiologists for the small amount of pain which they caused, and that, too, in the unselfish and beneficent pursuit of knowledge which is designed to mitigate human suffering and save human life. The agitation was incited by fictitious horrors, and was worked up and sustained in a business way by practised manipulators of popular passion and prejudice. It was directed against a certain class of scientific men, and had its chief root in those narrow prejudices against science which the press and the pulpit have recently done so much to nourish and sustain. There has been an especial dread of biological science, because it meddles with the mysteries of life, and aims to explain things which ignorance and superstition would rather not have explained. Experiments upon animals are looked upon with abhorrence, not solely because of the creatures' suffering, but also because the knowledge thus deduced and applied to man is held to be derogatory and degrading to his nobler nature. The anti-vivisection movement, in short, was very much a result of that feeling of jealousy and hostility toward science which is by no means confined to the ignorant classes, and which it was not difficult to inflame into the fanatical intensity of an aggressive and intolerant popular movement.

POLITICAL ECONOMY IN THE UNITED STATES.

THE hundredth anniversary of Adam Smith's "Wealth of Nations" has been the occasion in England of a pretty careful review of the science which he founded—its methods, its province, its achievements, and its prospect of future usefulness—with the result, not of reaching definite conclusions, but of revealing very wide differences of opinion as to what political economy really is. The general tone of the discussion is decidedly doleful; dissatisfaction with the present and doubt as to the future being the only points upon which there is unanimity. Politicians and newspapers alike declare that the centennial marks the decline and not the consummation of the "dismal science;"

that the points of the present controversies are not of the same importance as those of earlier days; that there remains not much to be done in the way of direct legislation; in short, that its great work is done.

In a sense this may be said to be true. The repeal of usury and corn laws, and the establishment of free trade, *was* a great work; and in many minds this practical application of principles stood for the science. Being accomplished, it forms so essential a part of the commercial policy of the country, and has become so rooted in the minds of the present generation, that the value of the benefits derived is not duly appreciated, nor the importance of extending this work to other countries sufficiently recognized.

Economical reform in England has reached that critical period, which comes in the history of all reforms, when effort has been crowned with success. Its old rallying-cries have lost their potency because the ideas which they represented have become universally-accepted axioms; the evils which it labored to correct no longer exist; its champions find their old weapons useless, and no new ones are, as yet, fitted to their hands.

Naturally, this chaotic condition has begotten dissension and revolt, even among those who are by no means willing to admit that the functions of the science have become unimportant; the ranks of the faithful have fallen into disorder; rival sects have arisen, and the validity of time-honored tenets is discussed with earnestness if not with heat. The orthodox school still holds in the main to the old creed; while the dissenters, styling themselves the Historical School—a name the fitness whereof their opponents decline to allow—denounce this creed as being based upon rude generalizations, obtained by a superficial and unphilosophical process of abstraction.

We shall not, at this time, attempt any discussion of these questions. We have faith in political economy as a science, and a perfect assurance that, whatever subdivision or specialization it may undergo, its vitality will remain unimpaired. We could, therefore, look upon the present contention with equanimity were it not for the reflection that, here in America, we are still disputing over those economical principles which in England are irrevocably settled.

However true the statements that the science has outlived its usefulness may be with regard to that nation, they have no application to the condition of the United States. Here its most fundamental propositions are matters for discussion and legislation, and the problems involved imperatively demand solution. We who, this year, are celebrating the hundredth anniversary, not of a book, but of the nation's birth, have still to decide whether the progress over which we are prone, rightly enough, to indulge in a good deal of self-glorification, has been helped or hindered by the policy of protection which has ruled hitherto; whether, had an opposite course been pursued, our internal resources might not have been quite as fully developed, and at the same time our external commerce have received a commensurate impetus instead of being at its present low ebb. This, and the condition of our currency, are very real questions with us; the way in which they are answered may make all the difference between continued progress and comparative immobility; and yet, while the country is in a ferment from shore to shore over the most inconsequential of elections, these important matters lie apparently dead in the public mind.

The profound stagnation of the commercial world has brought us nearly to a stand. Old combinations are disturbed and broken up. In the lull some of the hallucinations of speculative fever are disappearing, but the

state of our finances is notoriously unsatisfactory, and that which Mr. Lowe is pleased to call the "great work" of political economy, the establishment of free-trade principles, with us remains undone. Is it not time seriously to consider what can be done to make the readjustment of the social elements a favorable one for us—one more adequate to the exigencies of the time?

Prolonged immunity from wars, the sway of sound commercial doctrines, the absence of the element of uncertainty in her finances, has enabled England to absorb a great part of the exchange business of the world. Continental disturbances made her opportunity, and she was ready to improve it. London is a vast clearing-house, while the United States do not act as middle-man between any two nations.

It is almost universally admitted that there can be no peaceful settlement of the Eastern question which can be lasting. Sooner or later it must be submitted to the arbitrament of war, and when that comes England cannot stand aloof. Engaged in such a struggle, she can no longer offer so secure a refuge as formerly to capital seeking a place of safety and stability. She must relinquish, in part at least, this function, and there is nothing mercenary in the suggestion that that would be our opportunity. But, however favorable for our aggrandizement foreign complications might become, they would now find us unprepared to take our rightful place in the world's commerce—unable to arrest the hour. Economical reform is an essential preliminary to success in such an endeavor. Our distance from Old-World centres finds compensation in our freedom from European entanglements; but the obstacles presented by a cumbrous and oppressive tariff, and a depreciated, fluctuating currency —compared with which three thousand miles of ocean are as nothing—would be simply insurmountable. And what is the prospect of their removal?

The answer which must be given is not satisfactory.

There is reason to believe that the vagaries of inflationists are giving place to sounder financial views. There is warrant for the hope that the friends of free trade are increasing in numbers, and that its principles are slowly gaining ground, but no demonstration of this by legislation has yet appeared—nor are there any signs of it. Neither set of politicians seems to consider them worthy of consideration. Meantime the forces of protection are in close order, well appointed and alert—they will make a stout fight, and that there should, at this critical period, be a disaffection anywhere in the ranks of sound political economy, must be regarded as a matter of the gravest concern.

PROFESSOR MARTIN ON SCIENTIFIC EDUCATION.

Lady Burdett Coutts, who, having much money to give away, patronizes numerous charities and receives great applause, has come to be a kind of authority in the sphere of philanthropy, duty, ethics, etc. Hearing much said against science, on account of the experimental study of animals, she sought Prof. Tyndall, to inform him that science was growing *immoral*, because it did not formerly do such dreadful things as it is in the habit of doing now. Prof. Tyndall replied that it was rather growing *biological*, or passing into a new sphere to explore the laws of life, to which experimental investigations on organisms *in life* are indispensable.

This comparatively new subject, biology, which, after three centuries of preparation in physics and chemistry, has only been fully reached by the scientific mind of the world during the last fifty years, is now beginning to be recognized in its full import in our system of higher education. Biological chairs have been founded, and laboratories and schools of biological research

have been established in connection with various of the old European universities; and although we, in this country, have had chairs, and schools, and museums of natural history, connected with our colleges, or apart from them, yet the provision made for biological study in the organization of the Johns Hopkins University at Baltimore marks a decisive step forward in the educational treatment of this important subject.

We give our readers the able inaugural address of Prof. Martin in entering upon his work at Baltimore, and they will be repaid by a careful perusal of it. The statement of principles, purposes, and plans, is excellent; and if they are carried out intelligently and perseveringly, as there is no reason to doubt they will be, the results cannot fail to be in a high degree advantageous. The proposed mode of combining original work with practical teaching is full of promise. Prof. Martin dispels the erroneous and injurious notion, too current, that original work means great discoveries. He points out how students of but ordinary capacity may yet do something to extend the boundaries of knowledge, while at the same time the important ends will be secured of mastering the true methods of inquiry, of making solid acquisitions, and of being able to teach from an actual understanding of the subject. What he says of the influence of scientific study, when conducted by proper methods, and in its genuine spirit, in cultivating the love of strict truth, and the mental habit of seeking it as the supreme thing, deserves the most serious attention. How to include a thorough discipline in truth-seeking, in our systems of education, is the problem of problems yet to be solved. No one who goes to church, or drops into the court-room, or visits our halls of legislation, or reads the newspapers, can fail to see that, with all their learning and volubility, our cultivated men are still very much in Pilate's state of mind in regard to truth. It may not be possible for all educated people to get the benefits of biological training as a part of culture, but the most salutary results will come from making scientific training an integral and established part of higher education. When thorough scientific culture once gets a fair foothold in our colleges and universities, so that its results can be compared with the purely literary training that now prevails, its influence will soon be felt, and we may safely leave the rival methods to the operation of natural selection. Meantime, our teachers will do well to consider carefully Prof. Martin's suggestions, and set themselves to the inquiry, how far it may be in their power to make application of them, in modified ways, in their own sphere of activity.

PROFESSOR HUXLEY ON THE HORSE.

We publish this month the third lecture of Prof. Huxley, as corrected by himself for The Popular Science Monthly, and accurately illustrated under the supervision of Prof. Marsh, of New Haven. The lecture deals mainly with the genealogy of the horse as traced far back into geological antiquity, by the discovery of successive fossil forms in successive strata or deposits. These forms are so closely related, and exhibit so graduated a series of modifications, as to establish the fact of a genetic and derivative relation from the lowest to the highest. The fossil terms of this series were already so far made out in Europe as to satisfy paleontologists there that the pedigree of the horse is established; but, by recent discoveries on this continent, the ancestral chain has been traced still farther back, so as greatly to strengthen the conclusion reached by foreign investigators. To the three ancestral forms found in Europe, which go back to what the geologists call the *Miocene*, Prof. Marsh had added two others, car-

rying the line back to the Eocene formations, and connecting the present Equus or horse-tribe with an early Eocene animal known as the *Orohippus*. In his lecture Prof. Huxley traced the relationship of these six ancestral forms of the existing horse, and based his argument for the demonstrative evidence of evolution on the continuity and extent of the series. But he went further, and stated what the characteristics of a still earlier form would be if it were ever discovered; and, within a month from his departure from the country, Prof. Marsh announces that fossils of the predicted animal have been actually found in the lowest Tertiary deposits of the West, giving the *Eohippus* as the seventh term of paleontological ancestry of the Equine group.

We pointed out last month that proof is a thing of degrees, and that demonstration may be cumulative; and the very case we were considering now furnishes further illustration of it. Prof. Huxley says that the doctrine of evolution and the Copernican theory of the motions of the heavenly bodies have precisely the same basis, that is, "the coincidence of observed facts with theoretical requirements;" and that "an inductive hypothesis is said to be demonstrated when the facts are shown to be in entire accordance with it." But the demonstration becomes still stronger when the requirements of theory lead to the prediction of what must follow from it, and Nature subsequently furnishes the facts that vindicate the prophecy. It is one of the highest tests of the truth of a theory, that it leads to new discoveries, as was conspicuously the case with the wave-theory of light. A scientific professor is reported to have said that the proof of the evolution theory is far less strong than that of the undulatory theory, while nobody regards *that* as demonstrated. On the contrary, it *is* so regarded, and with abundant reason. The objective existence of the ether may not be proved, but this conception is not essential to the theory, and is held by many as nothing more than a convenient assumption or hypothetical artifice to aid the imagination in picturing wave-actions. The essence of the theory, whether the medium assumed be ethereal or material, is that light originates in some kind of undulatory motion, and a rational optical science is now only possible on this view. In the sense in which Huxley uses the term demonstration, as "the coincidence of observed facts with theoretical requirements," it is an established demonstration, and evolution stands exactly on the same ground. The facts are what the theory requires them to be, and what it predicts them to be; it explains them by the operations of real causes, and offers the only explanation we can have without going outside of Nature to get it.

Prof. Huxley has done us great service by going over the question of evidence in his three lectures, and bringing out the full force of the proof for this doctrine, and to make any less claim than he has made is to be wanting in fidelity to the truth.

And from this point of view we must think that Prof. Martin, in his admirable introductory discourse, did not fairly represent the case in giving the scientific status of the principles of the conservation of energy and of natural selection. He said: "These ideas *may or may not* be true; increase of knowledge may confirm or may *possibly* upset them." So sharp an alternative as true or false, determinable only in a contingency of the future, certainly does injustice to the logical validity of these great ideas. They can no more be subverted or abandoned in the future than any other truths of experiment and observation. They may disappear by absorption into larger truths, may change aspects, but they are basal and permanent factors of science, and we see not why the professors

of physics and mathematics might not open their courses by conceding the insecurity of the fundamental principles of their sciences with just as much propriety as the professor of biology.

COMMERCIAL MANIAS.

RECENT writers upon the subject of commercial manias usually indulge in congratulations over the fact that the world is grown more wise; that the mental aberrations of our day are less marked than those of earlier times; that, for example, the absurd Dutch tulip-mania, Law's wild Mississippi scheme in France, and the South-Sea bubble in England, find no parallel in these days of greater intelligence and self-control; that the time has gone by when a sharper could clear $10,000 in five hours by selling shares in "a company for carrying on an undertaking of great advantage, but nobody to know what it is!"

It is probably true that our tendencies are not quite so rabid as those of our fathers, but we hold on bravely to some of their worst follies. It was only at the last session of Congress that the advocates of an unlimited issue of irredeemable paper were strong enough to prevent any steps being taken toward resumption. It was but the other day that the progressive Commonwealth of Massachusetts chose as a representative B. F. Butler, who declares that the "progressive" dollar is a paper dollar so issued that it can never be redeemed. The absorbing interest of a presidential election has hushed somewhat the clamor for the interconvertible note scheme —which is to pay all debts, public and private, and make everybody easy without costing anybody anything—but, had all those who still fully sympathize with the financial imbecility of Mr. Peter Cooper voted for him, the old gentleman would have had a very different showing in the official count. Nor are there lacking concrete examples of credulity which rival any of the exhibitions of former generations. A case in point is now running its course in Spain.

A woman has opened a bank in Madrid for deposits in sums of a hundred dollars and upward, on which she pays interest as follows: twenty per cent. on receiving the deposit, twenty per cent. at the end of the first, second, and third months, and then at the expiration of the fourth month, when eighty per cent. has been already paid, she reimburses the entire sum lent. The payments thus far have been regularly made, and the public are flocking in crowds with their money, the deposits now amounting to several millions of francs. The bankers and savings-banks are being drained of their deposits by this extraordinary traffic. Hours before the bank opens in the morning hundreds of depositors collect, and the presence of the police is necessary to preserve order. In this case "nobody is to know" how the money is employed, and on that point contrary rumors prevail; some assert that the capital is used in working mines of fabulous wealth; others, that the woman is an agent of the Government, adding that it is thus procuring money on more advantageous terms than with its regular bankers! The true explanation will not be long withheld, unless the police interfere to prevent her running off with her plunder. This is almost a precise repetition of a case which took place in enlightened Germany four years ago—the Spitzeder affair of Munich. In this case enormous sums were confided to a woman banker, who lived in opulence, squandering the money of her depositors, and, as she could not repay them, she was sentenced to three years' imprisonment. Her time expired some months ago, and the likeness of the transactions at Madrid to her operations at Munich is strong enough to suggest a common origin.

These cases appear still more re-

markable when we recall the fact that in Continental Europe the confidence in banks of deposit has never attained the strength that it has in this country and in England. Outside of strictly commercial circles and people of large means the practice of depositing money with a banker is comparatively unknown. Small dealers, mechanics, and farmers, still adhere, in the main, to the old custom of hoarding, in featherbeds or underground, that has descended from the troublous days of the middle ages. That men should go from the extreme of unfounded distrust of stable and well-managed institutions into the incredible folly of pouring their money like water into the tills of a barefaced swindler, would seem to show that the springs of human action have not been raised very much; that a love of great gains, a desire to get more than our money's worth, a credulous faith in the performance of impossible promises are still deeply rooted, and need but the stimulus of some new and untried humbug to develop an amazing number of credulous fools.

LITERARY NOTICES.

KNIGHT'S AMERICAN MECHANICAL DICTIONARY. A Description of Tools, Instruments, Machines, Processes, and Engineering; History of Inventions; General Technological Vocabulary; and Digest of Mechanical Appliances in Science and the Arts. By EDWARD H. KNIGHT, Civil and Mechanical Engineer. 3 vols. Pp. 2831; 7395 cuts. New York: Hurd & Houghton. Price (cloth), $8 per vol.

THIS comprehensive and valuable work belongs in the rank of the cyclopædias, although its author has seen fit to choose for it the less ambitious title of a dictionary. It is qualified as mechanical, and answers to this description, but mechanics goes deep and sweeps wide in the field of Nature and art. Indeed, philosophers are split into factions over the question how far mechanics actually extends in the economy of the world, some maintaining that even cerebral action in processes of thought is resolvable into mechanical elements and conditions. But, without going so far as this, it is indisputable that mechanical changes are extensively and profoundly involved in the ongoings of the material universe. It is a vulgar notion that the term mechanics is restricted to cog-work and belting, wheels, levers, and pulleys, and a glance at Mr. Knight's voluminous exposition of the present state of knowledge on mechanical subjects will quickly dispel the narrow notions that may have hitherto prevailed regarding it. As stated in his prospectus, "the work deals with the *mechanical side* of every subject that can be known or mentioned, and, as almost everything in the universe has a *mechanical side*, the work becomes encyclopedical."

Mr. Knight seems to be a man cut out for such an enterprise. He began it twenty-five years ago, and as the volumes, in their vast and accurate detail, abundantly show, he must have had an enthusiasm for the work that kept him at it with untiring patience and perseverance; but as mere industry, although a prime factor in the result, must have been insufficient unless acting in the most favorable circumstances, he went to the headquarters of opportunity in this country, the Patent-Office at Washington. He was here "engaged in the editing the Patent-Office Report" and classifying patents; and subsequently editing the *Official Gazette* and systematizing for examination the twenty thousand applications for patents which are yearly presented at the office. Sitting at the very centre and focus of the mechanical thought of the country, he had both the stimulus and the facilities for carrying out his long-cherished purpose, and the "Dictionary" no doubt owes its exhaustive completeness to the free command of facilities afforded by his position.

We know of nothing that more impressively illustrates both the great advance of knowledge in this sphere of science and art, and the great activity with which it is at present cultivated in all civilized countries, than a critical glance at the pages of this elaborate work. And its statements are so presented as to bring out this view most impressively. Mr. Knight has introduced a subsidiary feature of "special indexes," which is not only very useful to those who consult his work, but shows in a striking way the extent to which inventive

construction has been carried in special lines of inquiry. For example, under the term "metre," we have a list of 218 instruments or machines for measurement, the description of each being found under its proper alphabetical heading. "These specific indexes afford the reader an excellent opportunity for investigating thoroughly all that pertains directly or indirectly to any special subject, by using the index under the title of that subject as a sort of head-centre, and following out its various branches through all their ramifications."

The work includes about 20,000 titles, and gives an exhaustive vocabulary of the technical terms that are employed in various trades and manufactures, and many of which are not to be found in the current large dictionaries. The work is, in fact, little less than a mechanical library, summarizing an endless multitude of books, and bringing up its accurate information to the present time. Of people who read and think at all, it is hard to think of any class that will not find it serviceable.

A Course of Elementary Practical Physiology. By M. Foster, M. D., F. R. S., Fellow of, and Prælector in, Physiology in Trinity College, Cambridge. Assisted by J. N. Langley, B. A., St. John's College, Cambridge. Macmillan & Co. Pp. 244. Price, $2.00.

As the sciences come to be more and more studied, directly and practically, there arises the necessity for books of special guidance in laboratory-work. In chemistry, treatises upon manipulation are as old as the science, and in recent years various works have been published, instructing the student in physical manipulations. The same necessity is now beginning to be felt in physiological study, and Prof. Foster's little hand-book now appears to supply this want for English-speaking students. The book has grown out of Dr. Foster's practice as a teacher. When in University College, London, he was in the habit of distributing among his students a syllabus to guide them in their work. This became extended, by the introduction of details, into a practical course, which is now published for general use wherever physiology is pursued, experimentally, or by the observation and verification of its facts.

Dr. Foster recognizes that the introduction of the microscope has given a direction to manipulative activity that is not altogether favorable to broad physiological study. The importance of histology is not questioned, but the tendency has been to pursue it separately, and to a certain extent to accept it as a substitute for physiological work on a large scale. Dr. Foster thinks that microscopical investigation can only be best pursued in combination with a full scheme of physiological work. He says: "Histological work, unless it be salted with the salt, either of physiological or of morphological ideas, is apt to degenerate into a learned trifling of the very worst description; and students are generally only too ready to spend far too much of their time in the fascinating drudgery of cutting sections and mounting stained specimens." And again: "The student who has mounted an exquisitely and beautifully stained section is only just so much the worse for his pains (as far as physiology is concerned) if he does not understand what the section means. Hence, when the features of some of the fundamental tissues and the general working of the more important mechanisms have been really learned, and the student has got, by doing things for himself, to know the value of a physiological experiment, and the pitfalls that are hidden under carmine and Canada balsam, he may be safely trusted to fill in the details of his study by means of reference to mounted specimens and to mere demonstrations, or even to descriptions of experiments."

Though the work is elementary, and is designed to be introductory to the author's "Hand-book for the Physiological Laboratory," it is, nevertheless, comprehensive, and covers the ground that should be passed over practically by every well-educated medical man. When our medical institutions provide better for this form of study, we can trust ourselves more safely in the hands of their graduates.

The Religion of Evolution. By M. J. Savage, Author of "Christianity the Science of Manhood." Boston: Lockwood, Brooks & Co. Pp. 253. Price, $1.50.

The multiplication of works on the religious bearings of Evolution, against it and

for it, attests the strong interest that is taken in this aspect of the doctrine, and, as interest is ever the first condition of active inquiry, this deep concern about the religious import of the theory is of great advantage, no matter what the basis may be. Probably nine-tenths of the opposition to the doctrine is theological in its inspiration and its form, there being no end to the books which have been issued during the last dozen years to prove that it is anti-religious and atheistic. But the discussion has already led to a reaction, or to a modification of extreme views; that is, it is admitted, even by those who rank themselves as opponents of the doctrine, that it is not *necessarily* either atheistic or irreligious. But these assaults upon Evolution have, moreover, called out defenses of it on the part of the religious, which have not only been useful in concentrating attention upon the subject, but have been very valuable in their liberalizing influence, and the light they have thrown upon the problem of religion itself.

To those who care for the religious aspects of the question, whether as involving the religious sentiments to which the doctrine is claimed to be favorable, or the influence it is exerting upon theological belief, the present work may be decisively commended. Its author is a liberal Unitarian clergyman, who took up the subject in a series of Sunday discourses, which were subsequently revised for publication in their present form. His treatment of the subject, which is entirely in its theological relations, is able and independent, and is presented in a clear, spirited, and eminently readable style. He aims to show that Evolution is not destructive of the religious sentiment; that it favors the most exalted conception of God; that it brings Nature into harmony with elevated religious feeling, and must be of great service to humanity in sweeping away many superstitions that have grown up in times of ignorance and become associated and deeply involved with religious emotions. Mr. Savage is at no pains to conceal the fact that he is not orthodox, and avails himself of many opportunities to hit his theological opponents, but he can hardly be expected to start new fashions in the pulpit, and the opportunity of position in the argument is too tempting to be resisted. There are numerous passages in this volume that we should be glad to quote, as where he treats of the practical character of the discussion, the immense influence on the thought of Christendom of the Mosaic cosmogony, and his chapter on the "Evolution of Conscience," but our space will not allow of quotations. We must refer the reader to the volume, which he will find fresh, piquant, and instructive.

PUBLIC LIBRARIES IN THE UNITED STATES OF AMERICA: Their History, Condition, and Management. Special Report. Department of the Interior: Bureau of Education. Part I. Washington: Government Printing-Office. Pp. 1187.

THIS huge volume, which is the exponent of the public reading in this country, is an extensive cyclopædia on the subject of libraries. The statistics which have been published annually by the United States Commissioner of Education have been too limited to satisfy an inquisitive public, which wanted to know everything relating to books, from the arrangements necessary for organization to the best manner of preventing the volumes from being soiled.

This centennial offering will give much gratifying information to the true American, showing him that a great advancement has been made in the intellectual as well as in the material resources of the country. Thus, in 1776, there were twenty-nine public libraries in the colonies, containing 45,623 volumes. Now there are reported to be 3,682 libraries, numbering from 12,000,000 to 15,000,000 volumes, including pamphlets. Started in connection with the district-schools in New York and Massachusetts, free public libraries in some form have been established in the majority of the States of the Union; and it is believed that in no other country do so many libraries publish catalogues and reports.

The report is occupied with giving, first, the history of public libraries in the United States; second, their present condition and extent; third, a discussion of the various questions pertaining to library economy and management; fourth, extended statistical information of all classes of public libraries. Subjects comparatively new are introduced, such, for example, as the advisability of establishing professorships of books and

reading in connection with college libraries; or the beneficial results that would be produced by the employment of art-museums in free public libraries. The report has been well managed and is well arranged. The literature is especially good, as the greater part of the writing has been done by the various librarians throughout the country.

THE THEORY OF COLOR in its Relation to Art and Art-Industry. By Dr. WILHELM VON BEZOLD, Professor of Physics at the Royal Polytechnic School of Munich, and Member of the Royal Bavarian Academy of Sciences. Translated from the German by S. R. KOEHLER, with an Introductory Sketch by EDWARD C. PICKERING. Illustrated by Chromolithographic Plates and Woodcuts. Price, $5.

THE advantages of this work over others of a similar nature are derived from the fact that recognition is made of the recent progress in physiological optics. In the first part of the volume the theory of color is placed upon its proper basis in relation to science, showing the aid which the latter gives in the perception of colors, their system, and the law of mixtures. One of the leading features claimed for the book is its purpose to serve as a guide to the pictorial and decorative artist, giving him hints in regard to the color of leaves, of the sky, and of water; the use of Claude glasses; the effectiveness of small differences; the laws regulating the combination of colors, etc.

While the signature of the author is a good recommendation for the book, the names of Prof. Pickering and Mr. Koehler will greatly assist in the extension of its influence.

CHEMIA COARTATA; OR, THE KEY TO MODERN CHEMISTRY. By A. H. KOLLMEYER, A. M., M. D., Professor of Materia Medica and Therapeutics at the University of Bishop's College; Professor of Materia Medica and Pharmacy at the Montreal College of Pharmacy; and Late Professor of Chemistry, etc. Philadelphia: Lindsay & Blakiston. Pp. 111. Price, $2.25.

THE author has prepared this work "in the hope that it will prove useful to all who, from business occupation or from any other circumstance, may not have sufficient time at their disposal to consult the more voluminous works" which have been written. With the exception of brief introductory remarks to the different subjects, the book is composed of tables. The work is valuable merely from the convenience of referring to it, but could not be recommended to those who are beginning the study of chemistry, as there are many simpler and more comprehensive treatises on the subject.

NOTES ON BUILDING CONSTRUCTION. Arranged to meet the Requirements of the Syllabus of the Science and Art Department of the Committee of Council on Education, South Kensington. Part II. Commencement of Second Stage or Advanced Course. London, Oxford, and Cambridge: Rivingtons.

THIS second part is in no respect inferior to the first, and the interesting manner in which difficult subjects are discussed tends to fulfill the prediction that the different parts, when united, would make up a "body of principles on the subject of great value to practical men." Some of the subjects which appeared in the first part are here treated more minutely, and others of a more involved nature are introduced. Among the latter are "Centres," "Stairs," "Riveting," "Fireproof-Floors," "Painting," "Paper-hanging," and "Glazing." A third part is to follow soon, completing the work.

TWENTY-FIRST ANNUAL REPORT OF THE BOARD OF DIRECTORS OF THE ST. LOUIS PUBLIC SCHOOLS, FOR THE YEAR ENDING AUGUST 1, 1875.

FROM this report it appears that the number of pupils in the day-schools during 1874–'75 was 35,941; in the evening-schools, 5,751—showing a large increase in the latter. Of the day-school teachers, the males form but ten per cent. No discrimination is made in the salaries in favor of male teachers, and a competent woman, in the position of "supervising principal" obtains a salary of $2,200 per annum. The salaries distributed in the year reported amounted to $531,850. All departments of the public-school system are said to be in the most flourishing condition. In connection with the schools there is a public library which gives gratifying results of its usefulness.

PREHISTORIC REMAINS AT CINCINNATI. By ROBERT CLARKE.

THIS is valuable as a memorandum of the prehistoric remains found on the site of the city of Cincinnati, which have already been obliterated, or are fast becoming so, by the extension of the city. It shows careful research. The main object of the pamphlet, however, is the vindication of the claims to importance of the "Cincinnati tablet" (engravings of which are given) found in a mound on Fifth Street, in 1841, by Mr. E. Gest. One face is sculptured, in low-relief, with hieroglyphics, which, from their singular resemblance to Egyptian carvings, excited much attention. It was accepted as genuine for thirty years, when doubt was thrown upon it by several writers, and since then it has been by many considered as a fraud. Mr. Clarke now brings forward a mass of direct evidence to show its genuine character as a true relic of the mound-builders, which it would seem hard to contradict; and adds that many who for a time believed the tablet an imposture are now convinced of its genuineness. No explanation of its significance or use, however, is attempted, except incidentally. Archæologists will be glad to read this paper.

THE GREENSTONES OF NEW HAMPSHIRE, AND THEIR ORGANIC REMAINS. By GEORGE W. HAWES.

THIS is reprinted with a colored plate from the *American Journal of Science and Arts*. The greenstones referred to cover the upper end of the Connecticut Valley, and belong to the Huronian age, but the author considers them to have been formed from fine sedimentary deposits accumulated in still waters; that the metamorphic action under which they were consolidated was quiet or gentle in degree, far different from that which in the adjoining regions formed mountain-masses of granite and gneiss, and hence that their special location, in connection with the nature of the sediments, has determined the characters of the greenstone series. In certain of these rocks silicated remains of rhizopods and foraminifers are found, and Mr. Hawes figures some as seen under the microscope, with their natural colors. The pamphlet is an instructive one to geologists and mineralogists.

FILTH-DISEASES AND THEIR PREVENTION. By JOHN SIMON, M. D., F. R. C. S., Chief Medical Officer of the Privy Council, and of the Local Government Board of Great Britain. Printed under the Direction of the State Board of Health of Massachusetts. Boston: James Campbell. Pp. 96. Price, $1.

THIS book is well recommended by the Board of Health of Massachusetts, as it believes that, "if the practical suggestions made in it were acted on by all citizens, hundreds of lives now annually doomed to destruction would be saved, and the health and comfort of the people greatly increased." The work was originally published in England as a preface to a volume of excellent reports made by Government inspectors. The author first traces the characteristic diseases due to filth, such as diarrhœa, typhoid fever, cholera, etc.; next, the various forms under which filth operates; and, finally, the means to be taken to do away with its effects. He also discusses at some length the different closet-systems.

FIFTY YEARS OF MY LIFE. By GEORGE THOMAS, EARL OF ALBEMARLE. New York: Holt & Co. Pp. 420. Price, $2.50.

THE Earl of Albemarle was born in the last year of the last century, and his recollections cover much interesting historical ground. The position of his family brought him in contact with royalty from his early youth, and many illustrious persons, civil and military, figure in these pages. The narrative is written in a gossipy and contented manner, characteristic of a man who has lived a long and enjoyable life.

SEVENTH ANNUAL REPORT OF THE STATE BOARD OF HEALTH OF MASSACHUSETTS.

THIS report is the careful compilation of an able committee, and the popularity which it has obtained is justly deserved. The authors emphasize the fact that "it is expedient to keep practical questions of sanitary law and work constantly before the people;" and they have accordingly presented the matter very forcibly. Such subjects as "Rivers Pollution" and "The Disposal of Sewage" are treated in their relations to disease. Aside from its local worth, the report is valuable on account of the general principles discussed.

THE Davenport (Iowa) Academy of Sciences has sent us its first volume of "Proceedings," forming a neatly-printed book of 285 pages and 36 plates. Besides the records of meetings, catalogues of cabinet, etc., a large number of papers are included, which, although local in their nature, are yet of much general interest. Davenport is so situated as to afford many advantages to the student of Nature. The underlying limestone abounds in fossils of the Hamilton and Upper Helderberg groups; the rivers and ponds produce a remarkably fine development of molluscan life; while the close proximity of the prairies to the wooded bottom-lands affords a rich field for the botanist and the entomologist. This region was once the residence of a prehistoric people, who have left many obscure traces behind them, furnishing an abundance of material for the archæologist to ponder over. Among the essays are several reports of explorations of mounds at Albany, Illinois, and in the vicinity of Davenport, by Dr. R. J. Farquharson, and other archæological papers by C. Lindley, A. S. Tiffany, and J. D. Putnam; geological papers by W. H. Pratt; botanical matter by Dr. C. C. Parry, J. G. Haupt, and J. J. Nagel; lists of insects of Iowa and Utah, by J. D. Putnam; and studies upon land and fresh-water shells, by W. H. Pratt. This first volume is very creditable to the young Academy, and it is to be hoped a second similar publication may soon follow. We observe, by-the-way, that it is published "for the Academy by the Women's Centennial Association," and suggest that this would be an excellent way for our many societies of zealous women to spend their money in other cities than Davenport.

AN ELEMENTARY HAND-BOOK OF THEORETICAL MECHANICS, with One Hundred and Forty-five Diagrams. Pp. 146. Price 75 cents.—AN ELEMENTARY HAND-BOOK OF APPLIED MECHANICS, with Eighty-eight Diagrams. By WILLIAM ROSSITER, F. R. A. S., F. C. S., F. R. G. S. New York: Putnams.

THESE two volumes form a mean between the commonly-received elementary treatises on the subject and the more advanced works. While they are simple enough for easy comprehension, they contain many of the data necessary for an advanced student.

HENRY HOLT & Co. are just putting to press, in hope of having it ready by the end of the year, a "Classical Literature" by C. A. White, whose "Mythology" has been received with much favor. The book will contain biographical and critical notices of the leading writers in Sanskrit, Greek, and Latin, with specimens of their works, and some account of the relations of the languages.

PUBLICATIONS RECEIVED.

The Germ-Theory of Disease. By J. Maclagan, M. D. Pp. 266. London: Macmillan.

The Functions of the Brain. By D. Ferrier, M. D. Pp. 338. New York: Putnams. Price, $3.50.

The Carlyle Anthology. Selected by E. Barrett. Pp. 396. New York: Holt & Co. Price, $2.

David and Anna Matson. By Abigail Scott Duniway. Pp. 194. With Illustrations. New York: S. R. Wells & Co. Price, $2.

Octavius B. Frothingham and the New Faith. By E. C. Stedman. Pp. 50. New York: Putnams. Price, 75 cents.

An Alphabet in Finance. By Graham McAdam. Pp. 230. Same publishers. Price, $1.25.

Modern Physical Fatalism. By T. R. Birks. Pp. 311. London: Macmillan. Price, $2.25.

Geographical Surveys west of the One Hundredth Meridian (Wheeler). III. Pp. 681. With Plates. Washington: Government Printing-Office.

Chemistry Theoretical and Practical. Parts X. to XIV. Philadelphia: Lippincott & Co. Price, 50 cents each.

Proceedings of the Poughkeepsie Society of Natural Sciences. Vol. I., Part I., Pp. 150.

Prometheus. Weekly Magazine. Vol. I., No. 1. Pp. 28. New York: Charles P. Somerby. Price, $3 per year.

Proceedings of the American Chemical Society. Vol. I., No. 1. Pp. 80. New York: Trow & Co., printers.

Valedictory Address at the Indianapolis College of Medicine. By E. D. Foree, M. D. Pp. 19. Indianapolis: *Journal* print.

Report of the New York Meteorological Observatory. By D. Draper. Pp. 48. New York: *Evening Post* print.

Report of the Commissioner of Agriculture. Pp. 19. Washington: Government Printing-Office.

Field and Forest. Monthly. Vol. II., No. 5. Pp. 8. With Plate. Washington: The Columbia Press.

Mayer's Ontogeny and Phylogeny of Insects. *Also*, A Century's Progress in American Zoölogy. By A. S. Packard, Jr. Pp. 4 and 8.

Immediate Preparation and Early Resumption. By R. T. Paine, Jr. Pp. 31. Boston: A. Williams & Co.

A System of Marine Signals. By S. P. Griffin. Pp. 13. New York: Van Nostrand.

Appalachia. Organ of the Appalachian Mountain Club. Pp. 62. With Maps. Boston: A. Williams & Co.

Education and Progress: an Address by General T. M. Logan, of Virginia. Pp. 16.

Relations of Physical Health to Morality and Religion. By Rev. G. W. Cooke. From the *Herald of Health.* Pp. 8.

Death-Rate of each Sex in Michigan. By H. B. Baker, M. D. Pp. 16. Cambridge, Mass.: Riverside Press.

POPULAR MISCELLANY.

Deep-Sea Bottom Deposits.—The deep-sea bottom deposits found by the Challenger expedition are classified as follows by Mr. Murray, naturalist on the scientific staff:

1. Shore-deposits, and these are mud of a variety of colors, as blue, gray, green, red, also coral-mud and sands; 2. Globigerina ooze; 3. Radiolarian ooze; 4. Diatomaceous ooze; 5. Red and gray clays. To these may be added peroxide of manganese in nodules and grains widely diffused.

The character of the sea-bottom contiguous to the shores is determined largely by that of the adjacent lands. Thus coral-mud occurs in the vicinity of coral-islands, and volcanic products near volcanic districts.

This general feature of the coast extends in some cases 150 miles seaward; an exception was found, however, among the coral-islands of the Pacific, where the coral-mud occurs as a narrow band around the islands.

Globigerina ooze is the most abundant deep-sea deposit next to the clays. It does not occur in the inclosed seas in the Pacific north of latitude 10° north, nor south of latitude 50° south.

Radiolarians occur in most seas, but only in limited areas are they sufficiently abundant to give a distinctive character to the ooze. In the Antarctic Ocean a diatom ooze is found, and radiolarian ooze was brought up from the great depth of 4,475 fathoms — nearly four and three-quarter miles. The skeletons of these minute organisms are siliceous.

The red clay is the most abundant deposit, and below depths of 2,000 fathoms is very widely diffused. The skeletons of siliceous organisms are abundant in it, but calcareous shells are few, and in some specimens wholly wanting. The author seems to refer the origin of the red and gray clays to lavas, scoriæ, pumice, volcanic ashes, and possibly meteoric or cosmic dust; and adds, "If there be an ash after the carbonate of lime is removed by acid or other agent, this will be another source." But Prof. Wyville Thomson distinctly states that the red clay is essentially the insoluble ash or residue of calcareous organisms which form the globigerina ooze, after the calcareous matter has been removed; and this conclusion is confirmed by the very careful experiments made by Mr. Buchanan, who treated the ooze with dilute acids.

The author states that efforts to detect free protoplasm in the dredgings was attended by no definite result. Some specimens, however, assumed a jelly-like aspect, with flocculent matter when in spirits. This flocculent matter was found by Mr. Buchanan to be "sulphate of lime precipitated from sea-water, and the author infers that the so-called 'Bathybius' and the amorphous sulphate of lime are identical." In this connection he quotes a report on the subject by Mr. Buchanan which states

that "the substance when analyzed consisted of sulphuric acid and lime, and, when dissolved in water and the solution allowed to evaporate, it crystallized in the well-known form of gypsum; the crystals being all alike, there being no amorphous matter among them." Mr. Murray's conclusion is that in "placing Bathybius among living things the describers of it committed an error."

Eccentricity in Wood-Growth.—Mr. T. S. Gold writes as follows, in the *Gardener's Monthly*, concerning the unequal deposition of wood in growing trees but partially exposed to the action of the wind: "A choke-cherry sprang from seed in front of my piazza, close to it, and could only be moved by the winds laterally. The section of the trunk was elliptical, the longer diameter being nearly double the shorter. Since the tree has grown above the roof of the piazza the trunk is becoming less elliptical. A young plum-tree standing close by the side of an out-building was killed by mice, and the sprouts were allowed to grow. These were all elliptical like the cherry, and made most wood on the two sides. It appeared to me that the trees made wood where it was most needed, on the sides where the strain of the wind came. Sometimes the eccentricity is produced by large branches or large roots on one side of the stem, and in other cases these seem to have little influence." This accords with the view of Mr. Herbert Spencer, who, in the appendix to his second volume of "Biology," gives the history of an interesting course of experiments "On Circulation and the Formation of Wood in Plants."

Notes on the British Arctic Expedition.—Of the two ships constituting the British Polar Expedition, the Discovery, Captain Stephenson, wintered at Cape Baird, latitude 81° 40′; and the Alert, Captain Nares, at Cape Union, latitude 82° 30′. The site of the supposed "Open Polar Sea" was found to be occupied by a rigid sea of ice, called the Paleocrystic Sea, or Sea of Ancient Ice. The thickness of this ice is enormous, varying from 80 to 120 feet. This Paleocrystic Sea is no doubt the accumulation of many years, or even of centuries. The lowest temperature experienced by the expedition was 104° Fahr. below freezing, which is 20° below the minimum observed by the Polaris Expedition. The sun was absent 142 days. A sled-party from the Alert planted the British flag in latitude 83° 20′ 26″; but, as they had to hew a track through the exceedingly rough surface of this frozen sea, seventy-two days were spent in accomplishing the journey. Another party explored the coast-line westward for a distance of 220 miles. The most northerly point of the coast of Grant Land was found by this party to be Cape Columbia—latitude 83° 7′, west longitude 70° 30′. The Greenland coast was explored by a party from the Discovery, and its most northerly point found to be in latitude 82° 50′, west longitude 43° 30′; thence the coast trends in a southeastern direction. A good seam of coal was discovered near the winter-quarters of the Discovery. A brass tablet with the following appropriate inscription was fixed on the grave of the gallant American explorer, Captain Charles Francis Hall: "Sacred to the memory of Captain C. F. Hall, of the U. S. ship Polaris, who sacrificed his life in the advancement of science on November 8, 1871. This tablet has been erected by the British Polar Expedition of 1875, who, following in his footsteps, have profited by his experience."

Sexual Selection among the Monkeys.—Mr. Darwin, in his "Descent of Man," holds that the brilliant coloring of the face in the male mandrill, and of the posterior callosities in that and sundry other species of monkeys, is the result of sexual selection. He now, in a communication to *Nature*, brings forward some new observations on this subject made by Joh. von Fischer, of Gotha. Von Fischer finds that not only the mandrill, but the drill and three other kinds of baboons, which he names, also *Cynopithecus niger*, *Macacus rhesus*, and *M. nemestrinus* turn the hind-parts of their bodies, which in all these species is more or less highly colored, toward him when they are pleased, and toward other persons as a kind of greeting. Many other facts of a like nature are mentioned by Mr. Darwin, and then he expresses the opinion that "the bright colors, whether on the face or hinder end, or, as in the mandrill, on both, serve as a sexual ornament and attraction. Any-

how," he continues, "as we now know that monkeys have the habit of turning their hinder ends toward other monkeys, it ceases to be at all surprising that it should have been this part of their bodies that has been more or less decorated. The fact that it is only the monkeys thus characterized which, as far as at present known, act in this manner as a greeting toward other monkeys, renders it doubtful whether the habit was first acquired from some independent cause, and that afterward the parts in question were colored as a sexual ornament; or whether the coloring and habit of turning round were first acquired through variation and sexual selection, and that afterward the habit was retained as a sign of pleasure or as a greeting, through the principle of inherited association."

The Transmission of Habit.—A correspondent of *Nature*, resident in New Zealand, communicates to that journal several instances of the transmission of habits to offspring in animals. One instance is that of a mare which would wander away from the "mob" of horses to which she belonged —always seeking one particular creek. When released from work she would make off to her favorite feeding-ground by herself. One of her progeny some years after showed a similar liking for solitude. Again, a valuable mare was an incorrigible kicker; she transmitted her special vice to her offspring. Peculiarity in the form of the hoof has been transmitted to generation after generation. The same writer states that a particular strain of Dorking fowls which he has had in his possession for thirty years always show a restless desire for rambling, and this, too, under the difficulty of meeting with much persecution when straying beyond their range.

Efforts to stop the Locust-Plague.—In October a convention of the Governors of several Western States and Territories was held at Omaha, to devise means of withstanding the plague of locusts. Besides the Governors, there were present at the meeting a number of prominent farmers and scientific men. A memorial to Congress was adopted, setting forth the serious injury done to agriculture by the locust, and asking for the appointment of a commission to investigate the "history and haunts of this insect; also all possible means of its extermination, and remedial agencies which may be used against it." Prof. Riley, of St. Louis, delivered an address, in which he briefly narrated the habits and history of the Rocky Mountain locust. He considered that there were two main questions before the conference: 1. How best to deal with the young insects that threaten to hatch out over a vast extent of the country next spring; and, 2. The investigation of the insect in its native home, with a view of preventing its migrations into the country to the southeast. Prof. C. D. Wilber, of Nebraska, gave an account of the various means adopted in different parts of the West to counteract this plague. Governor Pillsbury, of Minnesota, gave a history of locust-ravages in various countries. Governor Pennington, of Dakota, offered a series of resolutions "respectfully but earnestly urging that all our people in the States and Territories afflicted by the locust-plague, of all denominations and sects, offer up special prayers in their respective churches for deliverance from this great enemy."

Insect Fertilization of Plants.—For a year Mr. Thomas Meehan has been making observations and experiments to determine whether insects are of material aid to plants in fertilization. His results, which are published in the *Penn Monthly*, appear to favor a decision of the question in the negative. That insects sometimes fertilize and cross-fertilize flowers, he admits, but he holds that these cases are less frequent than they are supposed to be, and that, when they do occur, they have no bearing on the general welfare of the race. The chief arguments for the necessity of insect fertilization, says Mr. Meehan, are drawn from structure and not from facts of observation. Thus it is stated that *Iris*, *Campanula*, dandelion, ox-eye daisy, garden pea, *Lobelia*, clover, and many other plants, are so arranged that they cannot fertilize themselves without insect aid. But the author has inclosed flowers of all of these in fine gauze bags, and found that they produced seeds as well as other flowers that were exposed. And yet *Iris Virginica* and *Campanula* are common

illustrations of the supposed necessity of insect fertilization. In one plant experimented with in this way (*Baptisia*), seeds were not formed. This plant, in the author's opinion, may possibly require insect agency for its fertilization. He does not deny that flowers are *sometimes* fertilized by the aid of insects; but he does not admit that this mode of fertilization is very common. His conclusions may be stated as follows: 1. That cross-fertilization by insect agency does not exist nearly to the extent claimed for it; 2. That, where it does exist, there is no evidence that it is of any material benefit to the race, but contrariwise; 3. That difficulties in self-fertilization result from physiological disturbances that have no relation to the general welfare of plants as species.

Proposed International Geological Congress.—A committee appointed by the American Association has issued a circular addressed to geologists, announcing the proposed convocation of an International Geological Congress, to be held at Paris some time during the Exposition of 1878. It is proposed to make the Congress an occasion for considering many disputed points in geology, and to this end it is desirable that the Geological Department of the Exhibition should embrace—1. Collections of crystalline rocks, both crystalline schists and massive or eruptive rocks, including the so-called contact-formations and the results of the local alteration of uncrystalline sediments by eruptive masses. In this connection are to be desired all examples of organic remains found in crystalline rocks, including Eozoon and related forms. These collections should, moreover, comprehend all rare and unusual rocks of special lithological, mineralogical, and chemical interest, examples of ore-deposits and of vein-stones of all kinds, with their incasing rocks. As far as possible these collections should be limited to specimens of a size convenient for examination, and be accompanied with sections prepared for microscopic study.

2. Collections illustrating the fauna and the flora of the Palæozoic and more recent periods, particularly of such horizons as present a more critical interest to paleontologists from the first appearance or the disappearance of important groups of organic forms. It has appeared to the committee that the organic remains of the Cambrian, Taconic, or so-called Primordial strata merit especial attention in this connection.

These various collections should be explained as fully as possible by labels, catalogues, monographs, and maps.

3. Collections of geological maps, and also of sections and models, especially such as serve to illustrate the laws of mountain-structure. In the geological maps, regard should be had to various questions which deserve the special consideration of the Congress, such as the scales best adapted for different purposes, the colors and symbols to be used, and the proper mode of representing superficial deposits conjointly with the underlying formations. The secretary of the committee is Dr. T. Sterry Hunt, of Boston.

Comparative Dietetic Value of Meat and Eggs.—A writer in the *Scientific Farmer* estimates the food-value of one pound of eggs as a producer of force, i. e., the amount of work the pound oxidized in the body is theoretically capable of producing, at 1,584 foot-tons, and the value of one pound of lean beef, from the same point of view, at 990 foot-tons. As a flesh-producer, one pound of eggs is about equal to one pound of beef, as is shown by the following analysis quoted by the author:

ONE POUND OF EGGS.

Water	12 oz., 36 grs.
Albumen	2 oz.
Extractive	130 grs.
Oil or fat	1 oz., 214 grs.
Ash	28 grs.

Will produce at the maximum 2 oz. of dry muscle or flesh.

ONE POUND OF BEEF.

Water	8 oz.
Fibrine and albumen	1 oz., 122 grs.
Gelatine	1 oz., 62 grs.
Fat	4 oz., 340 grs.
Mineral	350 grs.

The author hereupon remarks as follows:

"A hen may be calculated to consume 1 bushel of corn yearly, and to lay 12 dozen or 18 pounds of eggs. This is equivalent to saying that 3.1 pounds of corn will produce, when fed to this hen, 1 pound of eggs. A

pound of pork, on the contrary, requires about 5½ pounds of corn for its production. When eggs are 24 cents a dozen, and pork is 10 cents a pound, we have the bushel of corn fed producing $2.88 worth of eggs, and but $1.05 worth of pork.

"Judging from these facts, eggs must be economical in their production and in their eating, and especially fitted for the laboring-man in replacing meat."

Qualifications of Medical Students.—At the opening of the medical session of Glasgow University, last week, Prof. McCall Anderson said few could doubt that a preliminary examination of candidates for admission to the classes was called for, but if proof were required it might be found in the answers given to the following questions submitted to candidates by one of the examining boards: "What is meant by the antiquity of man?" Answer: "The wickedness of man." "The Letters of Junius?" "Letters written in the month of June." "The Crusades?" "A war against the Roman Catholics during the last century." "The first meridian?" "The first hour of the day." "To speak ironically?" "To speak about iron." "A Gordian knot?" "The arms of the Gordon family." "The Star-chamber?" "Place for viewing the stars." "To sit on the woolsack?" "To be seated on a sack of wool." "A solecism?" "A book on the sun." "The year of jubilee?" "Leap-year." They could, the professor added, have appreciated this last answer all the more heartily had it emanated from one of the female medical students. It is, however, only just on women to admit that they are, as a rule, serious in their studies, and are not in the habit of joking examiners. There is, indeed, an earnestness of purpose in their efforts to compete with man which entitles them to respect, and even imitation.—*Pall Mall Gazette.*

The Struggle for Existence.—Prof. Alfred Newton, in his address to the Biological Section of the British Association, described as follows the effects consequent upon the introduction by man of foreign species of animals into newly-discovered regions: "Set face to face with unlooked-for invaders, and forced into a contest with them from which there is no retreat, it is not in the least surprising that the natives should succumb. They have hitherto only had to struggle for existence with creatures of a like organization; and the issue of the conflict which has been going on for ages is that, adapted to the conditions under which they find themselves, they maintain their footing on grounds of equality among one another, and so for centuries they may have 'kept the noiseless tenor of their way.' Suddenly man interferes, and lets loose upon them an entirely new race of animals, which act and react in a thousand different fashions on their circumstances. It is not necessary that the new-comers should be predacious; they may be so far void of offense as to abstain from assaulting the aboriginal population; but they occupy the same haunts and consume the same food. The fruits, the herbage, and the other supplies that sufficed to support the ancient fauna, now have to furnish forage for the invaders as well. The new-comers are creatures whose organization has been prepared by and for combat throughout generations innumerable. Their ancestors have been elevated in the scale of being by the discipline of strife. Their descendants inherit the developed qualities that enabled those ancestors to win a hard-fought existence when the animals around them were no higher in grade than those among which the descendants are now thrown. The struggle is like one between an army of veterans and a population unused to warfare."

Economy in the Use of Steam.—A series of experiments has been made, as we learn from *Iron*, upon the 80-horse-power engine at Portsmouth dock-yard, for the purpose of testing the value of a process, the invention of Mr. Marchant, of London, whereby steam, after having done its work in the cylinder, is pumped back into the boiler, to be re-utilized for steam-power. The advantage which the inventor claims for his invention is a considerable saving of fuel, because, inasmuch as it is economical to keep the boilers supplied with hot water from the condensers instead of cold water, it follows that to keep them supplied with steam direct from the cylinders must prove still

more economical of fuel. The experiments appear to have been successful. The engine one day was worked as an ordinary condensing engine, when it was found that the consumption was 1,176 pounds of coal in six hours, producing an indicated horse-power of 84.747. The next day the engine was driven with Marchant's steam-pumps connected with the low-pressure cylinder; the consumption of coal was now 1,158 pounds, while the indicated horse-power was 104.123. The ascertained work on the steam-pumps was six indicated horse-power.

Gathering Rock-Crystals.—Searching for rock-crystals is one of the recognized industries of the Swiss Alps, and the men who follow this vocation are known as *Strahlers*. The following notes upon the search for these crystals we take from the *Moniteur Industriel Belge:* The outfit of a *Strahler* consists of a bar of iron four feet long and bent at one end, a shovel, a pick-axe, a hammer, a stout cord, and a leathern sack. Thus equipped, he goes out to his work in the morning. He nearly always goes alone, so as to have all he may find for himself. For hours and hours he creeps along the sides of the rock, on projections of a few inches, over yawning chasms. When he descries a vein of quartz, he strives to reach it, but oftentimes this is a matter of extreme peril, and involving much labor; he must be very careful where he steps, and not seldom he must hew out a resting-place for his foot in the rock. Having reached the vein, he follows it and strikes it with his hammer. His practised ear tells him whether he has to deal with a "cavern," a "druse," a "pocket," or a "kiln," as the various kinds of cavities are called in which are found the crystals—whether attached to the walls or loose and mixed with sand. The most famous discovery ever made of monster crystals is of very recent date. Some hundred feet above the snow-line an apothecary of Bern saw a vein of quartz 60 feet long and from 4 to 12 feet wide. On working the vein, four hundred-weight of crystals were taken out; the larger masses were purchased for museums, while the smaller pieces were sold to opticians.

NOTES.

THE chemical laboratory for female students, in the new building adjoining the Massachusetts Technological Institute, has been thoroughly fitted up, and was occupied for the first time early in November.

FIVE specimens of ground coffee, chemically examined by C. H. Eddy, of Michigan University, were found to be adulterated to the extent of from 22 to 39 per cent. with chiccory. One package, labeled "Pure Mocha and Java," contained 23 per cent.; "Pure Rio," 25 per cent.; "Pure Java," 22 per cent.; "Royal Java," 31 per cent.; "Warranted pure government Java," 39 per cent. Besides chiccory, these prepared coffees consisted chiefly of peas, oats, starch, carrots, etc. In three of the five specimens no caffeine could be discovered.

WHITE-LEAD, as a pigment, is chiefly valued for its "body," and for the ease with which it is laid on; but it produces lead-poisoning, and also tends to lose its whiteness. Zinc-white is not open to these objections. Properly prepared, it has as good covering properties as white-lead, and the addition of magnesia in the manufacture makes it as easy to work; besides, it has no injurious effects on the health of those who manufacture or use it.

AN extensive deposit of plumbago has been discovered in Longswamp Township, Berks County, Pennsylvania. "The deposit," says the *American Manufacturer*, "is between seven and eight feet in depth, and the mineral is of the best quality. Similar deposits are supposed to exist elsewhere in the same region, and persons are now engaged in prospecting, but as yet no new discoveries have been made."

THE *Library Table* for November contains a good sketch of the life and works of Mr. Darwin, with portrait. A valuable feature of this periodical is its classified index to current periodical literature.

THE death is announced of the eminent French geologist, Charles Sainte-Claire Deville, at the age of sixty-two years. He was a native of the island of St. Thomas, graduated from the Paris School of Mines, studied the geology of the Antilles, and published the results of his investigations in 1856. Later he was Professor of Geology in the Collége de France. For many years he devoted himself to the study of meteorology, and to him in great measure is due the foundation of the Montsouris Meteorological Observatory.

No publications by professors or other *attachés* (*quære:* officers, students, resident

graduates?) of the Johns Hopkins University are permitted to be issued in the name of, or dated from, the university, without the consent of the professor to whose department the subject-matter belongs, or, in defect of such professor, of the head of the university.

THE *Engineering and Mining Journal* proposes to its readers the following problem in proportion: If the German Continental Gas-Light Company is able to declare 13 per cent. dividends on its capital of nearly $3,000,000, when paying $5.75 per ton for its coal, and charging $1.01 and $1.35 per thousand feet for its 15.9 candle-gas, what are the profits of the New York gas companies, which pay $6 per ton for their coal, and charge $2.50 per thousand feet for a poorer gas?

IN the School of Anthropology lately opened under the auspices of the Paris Faculty of Medicine, Prof. Paul Broca lectures on anatomical anthropology, M. F. Topinard on biological anthropology, M. Dally on ethnology, M. de Mortillet on prehistoric anthropology, and M. Hovelacque on linguistic anthropology. The course is open to the public.

SEVERAL members of the Paris Anthropological Society have promised each to write a will directing that his brain be sent to the society, for inspection and dissection. It is thought that, by procuring the thinking organ of persons whose habits and works are perfectly known, some light might be thrown on the laws of physico-mental organization. The scheme is anathematized by the leading religious newspaper of France, the *Univers*.

ON and about pistons and journals which have been lubricated with animal and vegetable oils, lumps of dirty matter are found, consisting of iron oxide and fatty acids. Dr. Schöndorff has found that the oil is decomposed by steam into glycerine and fatty acid, and that the latter attacks the iron, causing enlargement of the cylinder. He therefore recommends the use of heavy mineral oils as lubricators.

AN association has been formed and an estate purchased on the Sussex (England) coast, for building houses of a superior character, and on the most approved principles, so as to secure all the advantages depicted by Dr. Richardson as belonging to his "Hygeia," or City of Health.

THE great maritime canal connecting Amsterdam with the German Ocean was opened November 1st, with imposing ceremony. The canal is sixteen miles in length, and has at the sea-end a harbor covering 250 acres, which, however, is not quite completed.

IT is stated in *Land and Water*, as a fact beyond contradiction, that the choice English breeds of cattle have for some years not only tended to diminish in size, but also in robustness of constitution. The milk-yielding qualities of English cattle, too, are declining, so that the importation of cheese and butter is increasing enormously. This is strikingly the case with the Durhams, in which everything is sacrificed to form. In the finest strains of Durham cattle fecundity has been seriously affected, and the milk-secretion has become next to nothing.

THE loss, in 1875, to Russia, from the ravages of wolves, amounted to about 15,000,000 rubles. The number of cattle killed was 179,000; of sheep, etc., 562,900. In the government of Kalouga alone the wolves killed 8,200 geese and 2,000 dogs. The human lives destroyed by the wolves are estimated at 200 per year.

AT the fifth meeting of Russian naturalists, held at Warsaw, September 12th, proposals were favorably received to establish a zoölogical station on the Solovetzky Islands, and to request the aid of the Naval Department for dredgings in the Black Sea. Messrs. Grimm and Bogdanoff informed the meeting that they had undertaken two publications, a popular periodical, *Herald of Natural Science*, and a periodical in French or German, which would give to foreign readers brief notices of scientific work in Russia.

A MINER at Nitshill, in Scotland, lately committed suicide by blowing himself up with dynamite. He procured a parcel of the explosive, went into the middle of the street, lighted the fuse, and leaned over the dynamite. The man was blown to atoms, and, on the spot where the dynamite had been laid, a hole was made about three feet deep by two and a half wide.

A COMMISSION appointed by the Government of Prussia to ascertain sundry anthropological data, has reported that of 4,127,776 pupils in schools, 42.97 per cent. had blue eyes, and 24.31 per cent. brown; 72 per cent. had blond hair, 26 per cent. brown, and 1.21 per cent. black. With regard to the color of the skin, only 6.53 had brunette complexion.

IN a letter addressed to M. Dumas, of the Paris Academy of Sciences, M. Gachez asserts that vines may be protected from the ravages of the *Phylloxera* by planting "red maize" between the rows. The insect quits the vine and attacks the roots of the maize.

IN 1849, out of every sixteen men, women, and children, in England and Wales, one was a pauper maintained by the charity of the remaining fifteen. In 1852 one in twenty was a pauper, and in 1875 only one in thirty.

JOSIAH PARSONS COOKE, Jr.